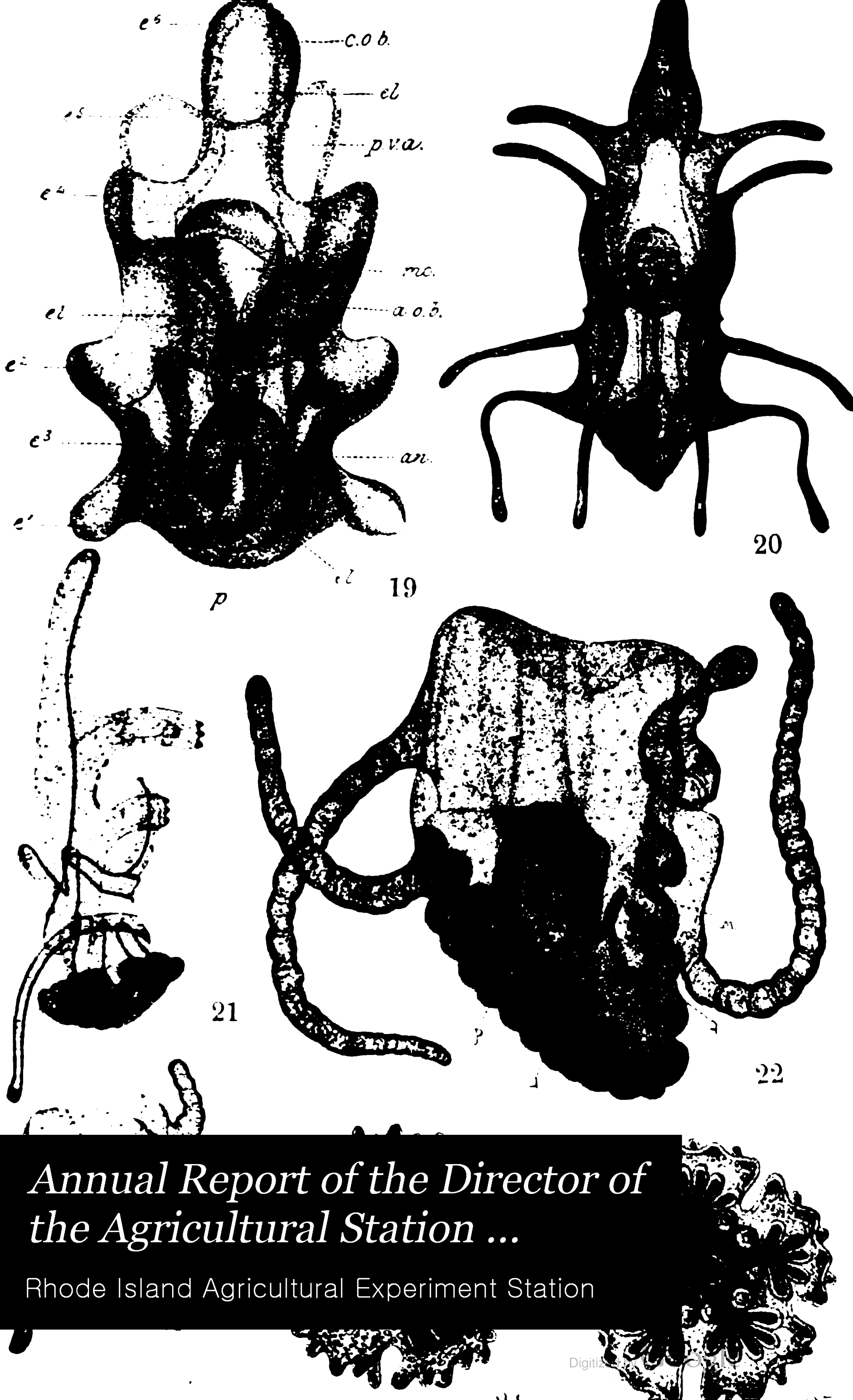

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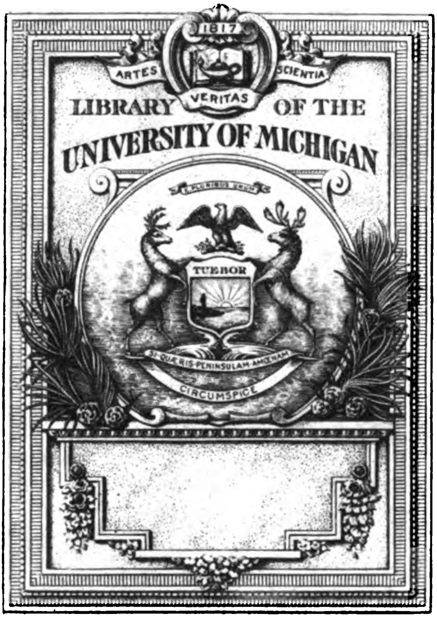
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STATE OF RHODE ISLAND
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State of Rhode Island and Providence Plantations.

TENTH ANNUAL REPORT

OF THE

RHODE ISLAND

AGRICULTURAL EXPERIMENT STATION,

1897.

PART II.

OF THE

TENTH ANNUAL REPORT

OF THE

CORPORATION, BOARD OF MANAGERS,

OF THE

Rhode Island College of Agriculture and Mechanic Arts,

MADE TO THE

GENERAL ASSEMBLY AT ITS JANUARY SESSION, 1898.

[PART I. OF THIS REPORT — COLLEGE CATALOGUE — IS PRINTED UNDER SEPARATE COVER.]

PROVIDENCE, R. I.
E. L. FREEMAN & SONS, PRINTERS TO THE STATE.
1898.

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OF THE

RHODE ISLAND

College of Agriculture and Mechanic Arts.

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[1]Resigned November 1. [2]Resigned December 1. [3]Five-sixths of time devoted to college work. [4]Resigned March 1. [5]Commencing February 1. [6]Resigned September 1.

The publications of the station will be mailed free "to such individuals actually engaged in farming as may request the same." The station desires the co-operation of the farmers of the State in the work of investigation, and any facts concerning unusual animal or vegetable growth or disease are solicited. Visitors are always welcome. Railroad station, telegraph, express and post-office—Kingston, Rhode Island.

LETTER OF TRANSMITTAL.

To His Excellency Elisha Dyer, Governor, and the Honorable the General Assembly of the State of Rhode Island, at its January Session, 1898:

KINGSTON, JANUARY 31ST.

I have the pleasure to present herewith, in compliance with the statute of the State and the Congressional act of March 2, 1887, the Report of the Director of the Rhode Island Experiment Station.

Respectfully submitted,

For the Board of Managers,

C. H. COGGESHALL,

President.

REPORT OF THE DIRECTOR.

There has been a number of changes in the staff of the Experiment Station during the past year. On March 1st, George M. Tucker resigned as assistant agriculturist, for the purpose of continuing his studies and observations during a three years' course in the universities and agricultural institutes of Europe. Joseph A. Tillinghast was appointed assistant agriculturist in his place. September 1st, Charles L. Sargent, who had been assistant chemist for over three years, resigned his position, to continue his studies at the University of Michigan. November 1st, Director Flagg, who had been with the institution from the first of its existence, resigned, and at the same time, the president of the college was appointed director *pro tem.*

During the past year, the poultry department has been moved from directly in front of the college buildings to leased land, which seemed to be a more suitable place for the department. A pot house has been built which will be used for experiments, conducted under the direction of Dr. Wheeler, for the purpose of corroborating those already in progress, on a much larger scale, in the field.

A laboratory has been built for the prosecution of the investigations of Dr. Field, at Point Judith Pond, a report of which experiments is appended.

Bulletins Nos. 43–46, inclusive, have been published during the year. These, with much information given to farmers personally at the Station and through correspondence, constitute a portion of the work which has been in progress at the Station during the

past year. Reports from the heads of the different departments are herewith submitted.

On June 1, 1897, a note from the Secretary of the State Board of Agriculture, George A. Stockwell, calling the attention of Director Flagg to a law passing the General Assembly on May 21, 1897, removing the work of fertilizer control from the Experiment Station to the State Board of Agriculture, was the first intimation that the officers of the Station had received that there was any desire for change of such work on the part of any one. Shortly after the receipt of the letter all the property, samples of fertilizers and records, such as could be in any way of service to the Board of Agriculture, were turned over to its representative by the chemist of the Station.*

* Before this report goes to press, a law, supported by the farmers of the State, requesting the General Assembly to remove the work of inspection from the direction of the State Board of Agriculture and place it under the direction of the Board of Managers of the college, has passed the Legislature, on March 1, 1898.

BIOLOGICAL DIVISION.

POINT JUDITH POND.

GEORGE WILTON FIELD.

The second season's work on the biological conditions of the pond has shown marked progress. The purpose of the investigations carried on there is to determine the economic value of this and of the similar areas of brackish water so extensive on the Rhode Island coast. It is hoped that we may be able to ascertain whether such areas may not be utilized for growing crops of marine animals in a manner analogous to that pursued in raising the ordinary farming crops. Crops of marine food animals and plants can be sown and gathered from the water or the bottom.

Success in marine farming depends upon an intimate knowledge of the conditions which obtain. These conditions are vastly more complicated than those with which the land-farmer has to deal. But the returns per acre are relatively so much greater as compared with farming lands that the study and experimentation involved have proved to be amply justified.

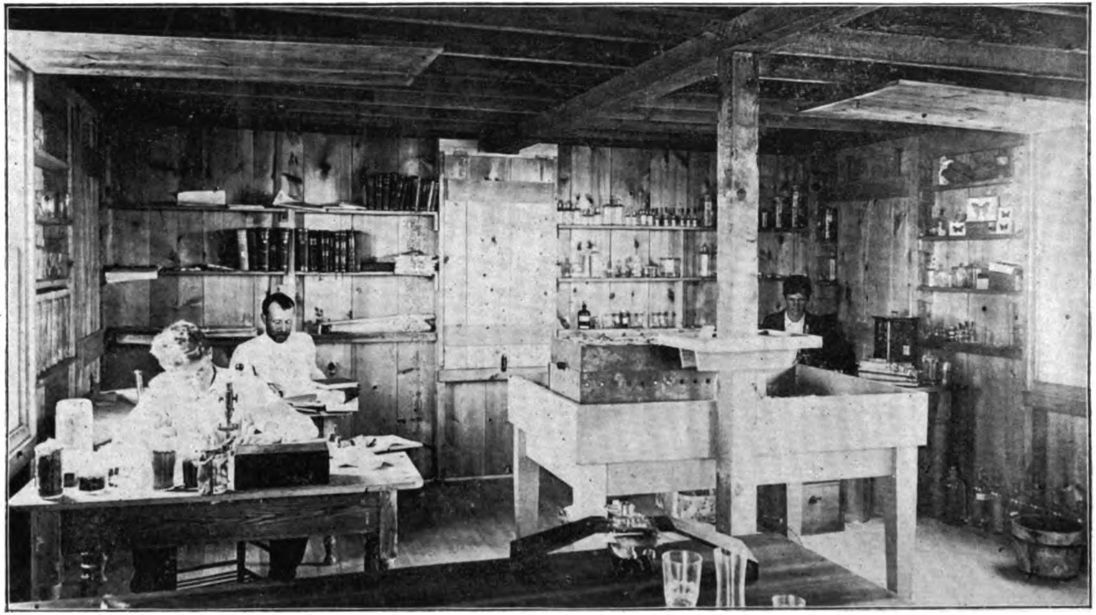
That the investigations might be carried on under more favorable conditions, a suitable but inexpensive building has been erected on Buttonwood Point. Through the courtesy of Messrs. E. F. and A. H. Watson, the Experiment Station was enabled to lease for five years, free of expense, a small tract of land with approaches and shore. The laboratory is a frame building suita-

ble for use throughout the year in ordinary weather. It is equipped after the manner of the general seaside laboratory, and has accommodations for four to six investigators. It is a pleasure to acknowledge our indebtedness to the friendly neighbors, who, by numberless kindnesses, have furthered our work by making our stay enjoyable and profitable. To several of the fishermen we are also indebted, not alone for advice, for knowledge of the pond, and for specimens, but also for the fact that they have personally protected not only the property on Buttonwood Point, but the animals and apparatus in various parts of the pond. So effectual has been the force of their opinion and coöperation that it has not been found necessary to prosecute anyone for interference with United States government property, though our work has been to a slight extent interfered with through the thoughtlessness of pleasure seekers on the pond. In the main, however, the people have been very prompt to see that the results of the work are to redound to the benefit of the inhabitants, one and all, and to appreciate the fact that each one can do something to aid.

As soon as means permit, the investigations will be extended so as to cover not only the oyster question, but also the biology of the clam and quahaug, and the principal food fishes of the pond (white perch, herring, eel, flat-fish, smelts, etc.).

Thus far our work has been mainly on the oyster, and the second season's work confirms the conclusions reached last year, and given in our annual report for 1896. (Annual Report of Rhode Island Agricultural Experiment Station for 1896, pp. 173–186.) We are more strongly than ever of the opinion that a permanent breach is of vital importance to the permanent value, and even to the perpetuation of the pond. There are indications that the breach tends each year to remain closed for a longer period, resulting in the deposition of a greater quantity of sediment, with the two-fold result of killing the oysters and of ultimately transforming the beautiful sheet of water to a miasmatic bog-hole. The set of oyster spat seems to diminish annually, owing to the diminishing number of adult oysters, brought about mainly by smothering in

Biological Laboratory at Point Judith Pond, R. I.



Interior of Biological Laboratory at Point Judith Pond, R. I.

the mud which is deposited, and to the fact that the young oysters find, each year, fewer and fewer points for attachment, on account of the covering of slimy mud, hence a greater percentage perish at the time of attachment. Observations have been made for suggestions as to methods of ensuring a permanent breach, and these will be embodied in our next report if they prove to be of sufficient importance.

In the fall of 1896 we planted eight bushels of scallop sets off Great Island Causeway, but they fell a prey to unfavorable conditions, viz.: the fact that the breach remained closed nearly the entire winter, and that many of the live scallops were "found" by appreciative fishermen is the probable cause of their death.

In September, Mr. Alonzo Jacoy and party brought into the laboratory two specimens of the "File" or "Trigger-fish" (*Ballistes carolinensis*). They were immature (about 3 inches long) and were caught on a hook. The full grown fish, as occasional stragglers from the southern seas, are taken with considerable regularity during the summer months in the nets off shore as far north as Cape Cod, but the presence of the young fish in the pond is worthy of note.

Early in November we found two other specimens of this species, evidently from the same school. One was dead and was being eaten by a crab. The other was floating, belly up, at the surface; when picked up it made a faint struggle. When placed in a bucket of warm (70° F.) water it quickly revived and seemed perfectly normal, and remained so until the water cooled during the night. In the morning the water again became warm, and the fish assumed the normal condition. The experiment was repeated with the same results, showing that the fish died neither from the lack of food nor from the condition of the water (*i. e.* pollution, salinity, etc.), but solely from the effect of temperature. The cold affected the protoplasm to such an extent that the organs ceased to perform their functions.

METHODS IN PLANKTOLOGY.

GEORGE WILTON FIELD.

Human existence is dependent upon the oceanic fauna and flora far more than is generally suspected. Scientific investigation has demonstrated a most remarkable biological chain, and has elucidated some of the links which connect the lowliest of the microscopic plants with the most highly developed mammals. In the continual cycle of matter from inorganic to organic, from organic to inorganic, with the attendant alternate storing up and liberation of energy, are to be found the secrets at the basis of life. It is commonly held by biologists that life originated in the sea, and it is in the sea to-day that we find those plants and animals which have departed least from the original, the ancestral condition; in which life is not complicated by diversity of form and function.

Some of the work carried on by the biological department of the Rhode Island Experiment Station has been upon the Methods of Studying the Oecology of Marine Organisms, since a knowledge of the marine organisms is of immense importance in understanding the questions connected with the fundamental food supply on the earth.

The number and variety of the animal and vegetable population of the ocean are well nigh infinite. Any two regions more or less remote from each other show differences in their oceanic fauna and flora, generally proportional to the distance, either horizontal or vertical, which separates them. The fauna and flora of the tropical Caribbean Sea differs widely from that of the Arctic ocean ; that of

the water south of Cape Cod differs markedly from that north of the Cape, though separated only by a very few miles of land. The organisms characteristic of the surface in any region are wonderfully different from those of the abyssal depths. Yet even in the same locality remarkable variations are the rule. These variations are conditioned not only by temperature, specific gravity, atmospheric pressure and light, but probably by other fundamental phenomena of which science as yet knows nothing. Certain forms spend the day in the depths, appearing at the surface only at night; for various forms the reverse is true. There are other temporal differences—yearly, monthly, daily and hourly variations—whose causes are manifold, in part climatic or meteorological, in part depending upon the conditions of life, of reproduction and development. Other variations are brought about by the numberless currents great and small, which not only collect the organisms into eddies, and scatter the "schools," but transport organisms characteristic of one region to places far remote from their home, *e. g.* the Gulf stream carries tropical forms far into the cold northern seas.

All the organisms which are borne about helplessly by currents, or whose motions are determined by protoplasmic activities (heliotropism, chemiotropism, etc.), as distinguished from special and effective locomotory organs, constitute the Plankton. (A word coined by Prof. Hensen from the Greek πλανᾶσθαι, to wander.) The Plankton has attracted the attention of scientists since the studies of Johannes Müller, but Prof. Hensen was the first to give earnest attention to the economic importance of the Plankton, and to the problems of food supply based upon it. He was led to this through his attempt to get an approximate idea of the number of fish in corresponding districts. This work led him to the question of the food supply for these fishes, and from that to consideration of the general primary sources of food and the cycle of matter in the ocean. This has led to many important results in tracing the cycle of changes through which the organic elements, carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, iron,

et al., pass; in showing how they, either singly or united in simple combinations, become incorporated into a living (it may be) microscopic plant, how this plant is eaten by a mollusc or a small fish, a prey in turn for larger and fiercer fish, which ultimately die and are broken up by microscopic plants (bacteria) into the original elements to again nourish plants. The actual cycle is rarely so simple as described above. Complicating conditions usually appear at every stage. Scientists are gradually unraveling these complications. But the point which is of special importance is that very many of these marine animals may furnish economical, healthful and delicious food for man. That this may be a never failing source of food supply for an increasing human population, not only must the habits, haunts and life histories of such food animals (fishes, molluscs, crustacea, etc.) be elucidated, but also their relation to natural phenomena, meteorological conditions, currents, etc., and especially to the Plankton upon which they depend more or less immediately for food. This necessitates study of the Plankton as the basis of food supply for our most important marine food animals.

Study of the economic aspects of the Plankton, and application of the results to cultivation of water areas, has demonstrated that water responds even more bountifully than land areas to cultivation. It is an interesting economic fact that less than fifteen cubic feet of cultivated water is sufficient to support at least the head of a family (and probably a considerable number of other dependents) of Italians in Tarente, while six cubic feet do the same in Japan. Numerous experiments demonstrate that the yield of cultivated water area surpasses in essential food elements that of equal area of cultivated land. Herein lies the great importance of a knowledge of the Plankton, the basis of marine life. The Plankton also enters, as an important and, in certain aspects, as an undesirable element, into the question of municipal water supplies, and the necessity of healthful and palatable drinking water has stimulated not a little the study of the quantitative and qualitative constitution of the Plankton.

Since the time (1884) when Hensen entered upon his work of counting laboriously the number of organisms in known quantities of sea water, for the purpose of ascertaining the amount of living matter which exists in given volumes of water, and thus furnishing a basis for scientific aquiculture, much attention has been given to the methods of Planktology, and rapid progress has been made. The great desideratum even now is a rapid, simple method by which data can be obtained which can be used for comparison of all waters. Not until the invention of such a method can accurate and valuable comparisons be made.

At the basis lies the method of collecting the organisms from an accurately determined quantity of water. An ideal method is one which includes the concentration of the organic matter in a known quantity of water into a small known quantity of water, which quantity should be a convenient multiple of the original quantity. In the process not even the smallest of the bacteria should be lost. Counting and enumeration of individuals and species is necessary, together with an estimation as accurate as possible of the volume of the water, of the inorganic matter, and of the organic amorphous debris (plant and animal). The counting can best be done by the Sedgewick-Rafter method ('92 Rafter, G. W.). By this method a fairly accurate idea can be formed of the comparative volumetric and numerical proportions between the three main elements involved in the biological study of water; viz.: the living organisms, organic amorphous debris, and inorganic substances (silt, gases, and substances in solution). It would seem that the necessary data must be based ultimately upon the counting method until such time as a means can be devised for separating the living organic from the dead (both organic and inorganic) substance, and for determining the amount of each. In considering the quantity of living organisms not only the number but also the size of the individuals must be taken into account. Prof. Hensen introduced the counting methods for the purpose of determining the economic yield of the ocean in the same way as the farmer determines the useful yield of his fields and meadows, the annual

production of grass and grain. Prof. Haeckel, in stating his objections to this method, said: "the farmer determines the yield of his meadows, garden and field, by quantity and weight, not by counting the individuals. If instead of this he wished to introduce Hensen's new exact method of determination, he must count all the potatoes, kernels of grain, grapes, cherries, etc.; not only that, but he must also count the blades of grass in his plot, even every individual weed which grows among the grain of his field and the useful plants of his garden, for these also, regarded from the physiological point of view, belong to the 'total production' of the ground." (Translation in report of U. S. Commissioner of Fish and Fisheries for 1889 to 1891, pp. 565–641, of Plankton Studien, Jenaische Zeitschrift XXV, 1890.) It would seem as if Prof. Haeckel overlooked the fact that the farmer can readily separate the hay, etc., from stones, dead sticks and other foreign material. He can accurately determine the volume and weight of farm products. He does not have to contend in this connection with foreign substances such as silt, organic debris, etc., which render inaccurate determinations by weight and volume of the contents of water from ponds, lakes and oceans. It is these elements which thus far have prevented any apparent progress in establishing tables of the economic yield of water volumes, on the basis of weight, volume and number of individuals, which would be of value for comparison in determining the commercial importance of any area or any depth of water. It is the presence of an undetermined and locally varying quantity of organic debris which renders inaccurate the estimation of the economic value of water by means of the determination of the albuminoid ammonia.

Numerous methods of Plankton collecting have been devised; the most important of these may be grouped as follows:

1, by drawing a fine net through known volumes of water;

2, by passing known volumes of water through a filter of either (a) fine silk bolting cloth, or (b) fine sand, or (c) a combination of a and b.

1. The net and the method of using it have been subjected to much study by Hensen ('87 and '95), Apstein ('91, '92 and '96), Reighard ('94), Ward ('96 and '96a), Borgert ('96), Kofoid ('97), and others. From the net method it seems impossible to exclude several prolific sources of uncertainty in the results, viz.: (a) it is impossible to be *certain* of the quantity of water through which the net is drawn, and consequently of the quantity which passes through the net even in motionless water; (b) currents in the water almost hopelessly complicate the conditions; (c) the progressive clogging of the net cannot be avoided; (d) there is an actual loss of small individuals through the meshes of the net; (e) the long and complicated process must necessarily give varied results, due to personal variations in methods of work and to changes in the local conditions, *e. g.*, the rate of currents may vary from day to day; the quantity of silt may modify the filtering capacity of the net, etc. Any one of these sources of error is sufficient to invalidate the entire method, rendering the results worthless for comparison with the results of similar processes in different localities.

Under 2 (passing known quantities of water through a filter of fine bolting cloth) the sources of error are reduced but not eliminated; (a) the pressure of water forces certain small forms, *e. g.*, certain species of bacteria, through the meshes. Many of the very delicate forms may be broken up and destroyed; (b) failure to wash out all the individuals from the net. The method of pumping known volumes, employed by Kofoid ('97) is particularly good. The most apparent source of error is the control of the quantity of water pumped, and the possibility that the strong suction of the pump used may draw mud when the water is taken within a foot of the bottom. In the method of filtration through sand, as employed by Calkins ('91) and as improved by Jackson ('96) and by Whipple ('96), the possible sources of error are several, varying with the characteristics of the sand used, with the shape of the funnel, and with the nature of the organic matter in the water. Dr. Calkins says, "The sloping sides of the glass funnel

offer a surface for the settling of organisms, and the error arising in this way may be considerable. A water free from amorphous matter and zoogloea will filter very accurately, but a water containing these gives opportunity for error." Jackson ('96) adds: "this is undoubtedly due to the jelly-like character of the zoogloea, and to the fact that while adhering to the funnel sides itself, it also retains with it other organisms." . . . "Not only does amorphous matter and zoogloea readily adhere to the sides of the ordinary glass filter funnel, but the same is true of the gelatinous growths of the Cyanophyceae and of the flocculent threads of *Crenothrix*." Even Jackson's ('96) improvements in the sand filtration method, which reduce to a minimum the liability of error, cannot remove the defects inherent in the process itself. The defects noted by Whipple ('96) are involved in the method of concentrating the sample. (1) the funnel error, arising from the adherence of organisms and amorphous debris to the sides of the funnel; (2) the sand error, caused by organisms passing through the sand; (3) the decantation error, resulting from the adhesion of organic matter to the particles of sand, and from the capillary retention in the sand of the water used in washing the sand during decantation; to the above should be added (4) the destruction of the very delicate organisms by the sand in the process of decantation. The practical value of the method for comparative results in the hands of different workers is invalidated by the multiplicity of conditions affecting the results; among these are the nature and amount of the sand, the care and skill of the worker, and, particularly, the nature of the sample to be filtered.

Kofoid (Science, VI, 153, Dec. 3, 1897, On Some Important Sources of Error in the Plankton Method) found that filter paper (No. 575 Schleicher & Schüll) was more effective than the sand filtration method, giving 75 per cent. to 85 per cent. of the planktonts as compared with 40 per cent. to 65 per cent. given by the sand filters. Kofoid has detected the advantage of filtration through very delicate, porous media, and finds that fine infusorial earth is very efficient, and, in spite of minor difficulties connected

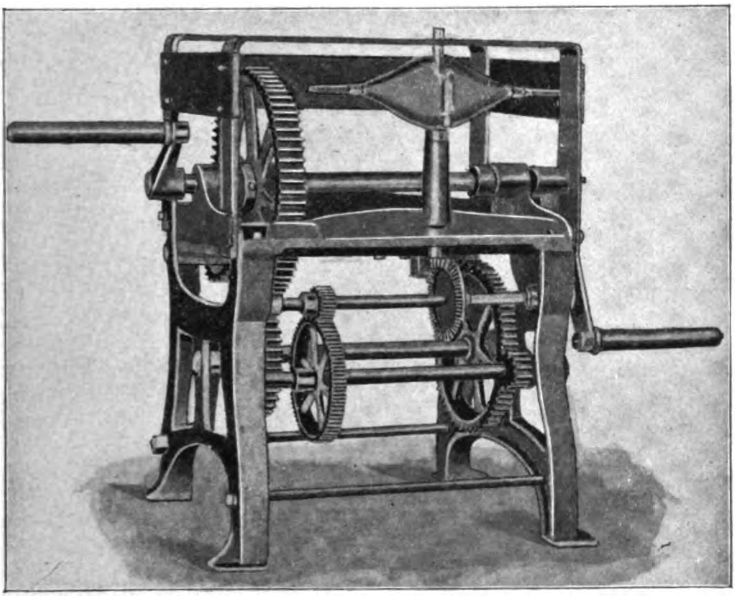


PLATE I.—THE PLANKTONOKRIT.

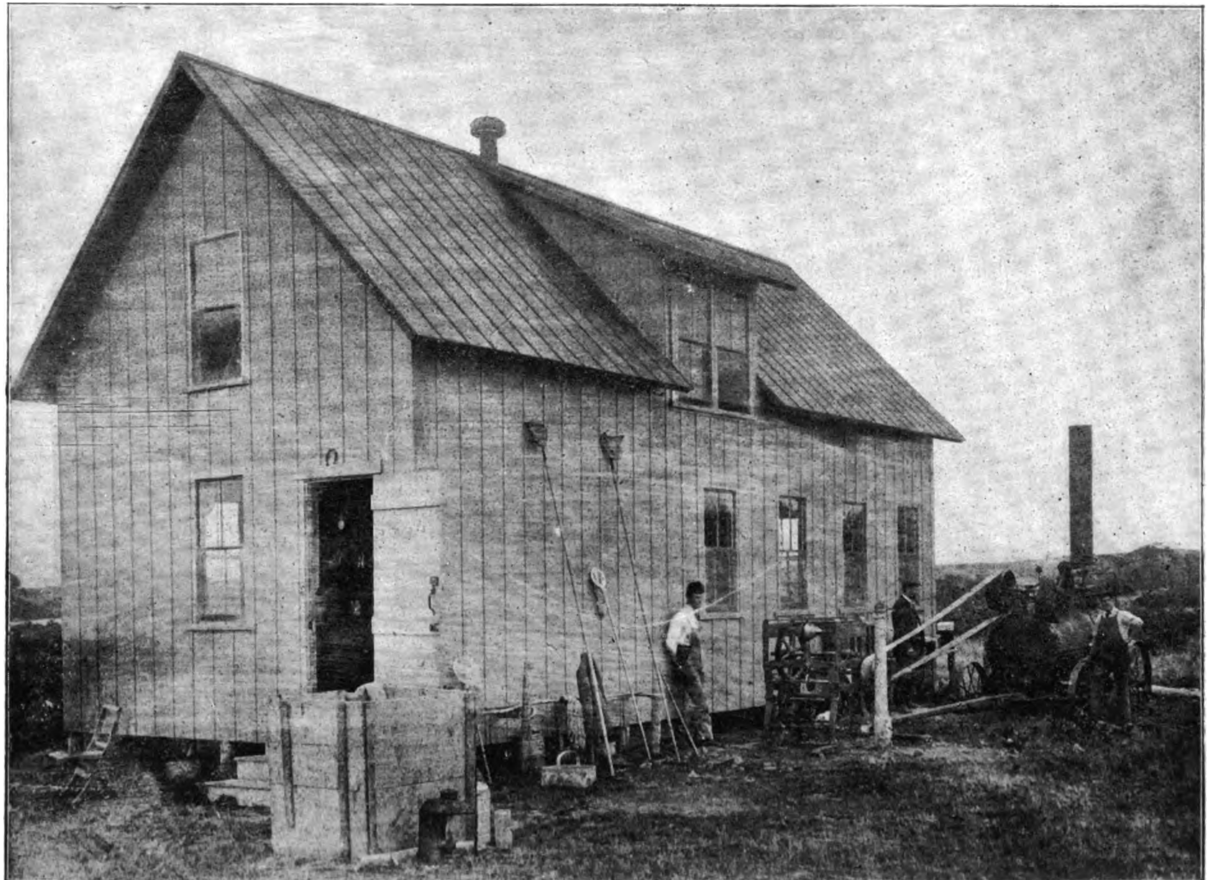


Plate II.—The Planktonokrit in Operation.

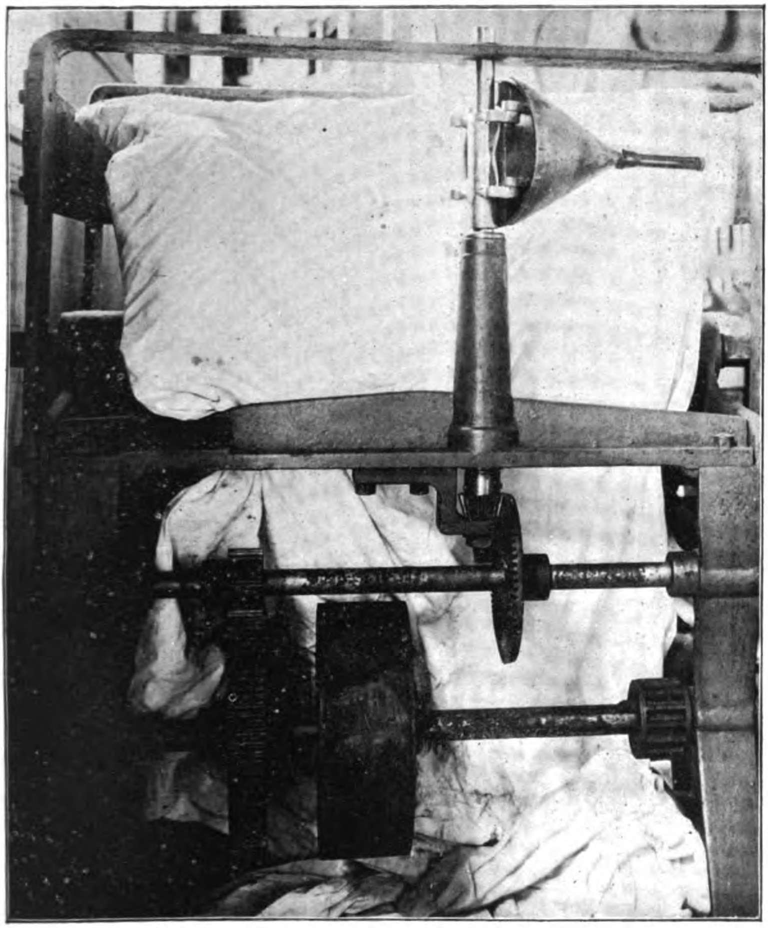


Plate III.—The Planktonokrit. (Showing details of the gearing.)
(Only one of the receptacles is in place.)

with the final separation of the planktonts from the infusorial earth, he regards this as the most satisfactory method thus far devised. I might add that the total weight of material (organisms, organic and inorganic debris) suspended in water is of fundamental importance and can be determined with considerable accuracy by this method, though I see no way to ascertain the relative proportion of organisms and debris except, very roughly, through the enumeration of the individual organisms and comparison of the apparent bulk of the masses of living and dead material, as seen under the microscope.

Experiments have been made by adding various quantities of either corrosive sublimate, picric acid, acetic and other acids, alcohol and formalin, to known quantities of water, with a subsequent determination of the volume and constituent elements of the precipitate. The space required, the tediousness, the loss of organisms, the fact that in this new process very many forms break up before all the material is settled, have led to its abandonment in favor of the employment of centrifugal force.

Previous to 1896 Cori devised a simple hand centrifuge and used it for collecting infusoria for class work. Last year a brief reference was made to our work with the centrifugal method. (Field, '97, I.) Since then Kofoid ('97) has experimented on similar lines. His machine is "geared to give 3,000 to 4,000 revolutions per minute and arranged to act upon a continuous stream of water, all of which was subjected to the maximum and uniform action of the centrifugal force." This machine secured in some instances 98 per cent. of the planktonts. But, as pointed out by Jackson ('96) and Field ('97 I.), it is not so efficient with those organisms whose specific gravity is about that of water, such as the Cyanophyceae, *Anaboena*, *Clathrocystes*, *et al.*

Our experiments have been made with the centrifugal machine devised by Dr. C. S. Dolley, called the Planktonokrit, and described by him (Dolley, '96): (see Plates I, II, and III) "An apparatus which consists of a series of geared wheels driven by hand or belt, and so arranged as to cause an upright shaft to revolve to a speed

of 8,000 revolutions per minute, corresponding to fifty revolutions per minute of the crank or pulley wheel. To this upright shaft is fastened an attachment by means of which two funnel shaped receptacles, of one litre capacity each, may be secured and made to revolve with the shaft. The main portion of each of these receptacles is constructed of spun copper, tinned. To this is attached the stem of the funnel, consisting of a heavy annealed glass tube of 15 mm. in outside diameter with a central bore of 2½ to 5 mm. These glasses are held in place and protected by a cover, such as is employed in mounting a water gauge.

The receptacle having been filled with the water to be examined, is caused to revolve for one or two minutes, when the entire content of suspended matter in the water is thrown down to the bottom of the tube, from which the volume may be read off by means of the graduated scale on the outside of the tube. The Plankton thus expeditiously secured can be transferred quickly to a vial or other receptacle, to be weighed or otherwise examined at leisure." Power may be applied either by hand or through a belt, by steam or electric motor.

Our experience with the Planktonokrit indicates

(1) That two men on each crank cannot get a speed at the receptacles above 3,000 revolutions per minute; a rate, however, sufficient to throw out everything except the Cyanophyceæ.

(2) The maximum speed must be continued for at least four minutes.

(3) A speed much above 4,000 revolutions with such a large quantity of water is dangerous, with the machine constructed as at present.

This danger may be obviated

(a) by reducing the capacity of the receptacles (500 c. c. is probably sufficient).

(b) by lengthening the bearings of the upright spindle.

(c) by enclosing the revolving receptacles in a circular chamber, thus lessening the resistance of the air.

(4) When power was used more satisfactory results were ob-

tained by putting the driving pulley as in Plate III, thus cutting out the two largest sets of gears (compare Plate I). Friction was thereby greatly reduced, and the necessary speed was gained from more rapid revolution of the driving pulley.

(5) It is probable that four receptacles would work more satisfactorily than two.

In working with the Planktonokrit invaluable assistance was rendered by the officers of the Mechanical Department of the college, and many of the above suggestions are owed to them.

Some difficulty was experienced in avoiding leaks at the ends of the glass tube. At the distal end the insertion of a closely fitting, vase-lined rubber "mushroom" (such as are used when repairing punctures in bicycle tires) was found to answer. Care had to be exercised to keep the entrance to the tube free at the proximal end. To obviate this difficulty, it is hoped that a small, heavy annealed glass cone with a ground class stopper at the apex can be devised in place of the tube.

That the centrifugal method is beyond question the best for collecting for accurate determination the substances suspended in the water seems to be proved, and great credit is due to Dr. Dolley for his demonstration of the fact.

This method is of value not alone to him who wishes to determine the proportions of organic matter in drinking water, and to ascertain the quantity of microscopic plants and animals in water from special localities (a very accurate index of its commercial value for fish and shell-fish cultivation), but it will enable biologists to study more successfully those lowly forms which lie close to the basis of life, the delicacy of whose structure precludes handling by nets or filters.

It is believed that the perfecting of the centrifugal method for collecting the Plankton will greatly facilitate the practical solution of the increasingly important question of the food supply for man, by ameliorating some of the difficulties which surround the rearing of edible fish in confinement. The eggs can be hatched by millions, but trouble arises in obtaining a natural or proper

food supply. Hence, in the case of most species the fry must be liberated very soon after hatching. But every additional day in which they can be kept in confinement increases in a remarkably large ratio the number of these young fish which attain maturity, for the reason that the very young fry are specially liable to destruction from rapacious enemies, storms, etc. With the use of the centrifugal machines for collecting the microscopic food for the young fry they can be kept longer in confinement, and probably the advantage may be two fold, for, in addition to diminishing the mortality, we should expect that growth would be accelerated under the influence of abundant food.

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THE STAR-FISH *(Asterias Fobesii)* IN NARRAGANSETT BAY.

GEORGE WILTON FIELD.

The common star-fish "or five-finger" of our bay cannot claim distinction, as do many of its relatives in other regions of the globe, for remarkable characteristics, such as strikingly beautiful colors, or wonderful diversity of form. Our species might well be termed the Quaker of the race. Its general appearance is typical, its colors sombre. But here the simile ends, for our "five-finger" is at once a scavenger, a destroyer, a thief. In these three words are summed up the bad and the good qualities of his being. Attention is arrested by his extinction of the beds of mussels, and of barnacles, upon which certain of our food fishes subsist. But since they rob the owners of oyster and scallop beds, and thus indirectly filch the public of thousands of dollars annually in this State alone, the consideration becomes eminently important, for the damage is so extensive that it is not compensated by the fact that as scavengers they remove great quantities of decaying animal matter from the bottom.

Since the development of the oyster industry, and the planting of large areas of sea bottom, the number of star-fish seems to have increased. This is either an actual increase in numbers, brought about by the favorable conditions for an abundant food supply, or an apparent increase due to the migration from all directions to the oyster and scallop beds. Whatever the cause, there is no doubt as to the existing numbers and the destruction wrought, a condition so important as to warrant the United States Fish Com-

mission in 1889 assigning the Commission steamer, "Fish Hawk," for a careful study of the ravages in Long Island Sound. The work was found to be exceedingly difficult and even more important than was at first supposed. That the damage is extensive and the loss enormous was first shown by Dr. Hodge's report, the as yet unpublished manuscript of which was furnished to us through the courtesy of the United States Fish Commission officials; how great this loss is may be readily seen from the following quotation, particularly when taken in connection with the figures on pages 161-2, which show that the number of star-fish have increased more than three-fold since Dr. Hodge's report:

"No estimate can be made of the damage, direct and indirect, which this pest has brought to the oyster industry of Long Island Sound since 1880. Mr. H. C. Rowe, of New Haven, the pioneer of 'outside' oyster culture in Connecticut, estimates that he lost during May and June of 1884, on a single bed, oysters to the value of $90,000, solely from star-fish. Besides this loss, the cost of dredging up the star-fish in this instance amounted to $9,000 more. Mr. Rowe gives this as a reasonable estimate in a single case. He, as well as most oyster growers, when asked to give such an estimate, replied that he could not estimate as loss what he has never had. What they estimate as actual loss is cost of planting and cost of fighting. If a bed is placed and no 'set' is obtained, the cost of planting, cost of shells, oysters and labor is put down loss to whatever cause may have prevented the 'set,' and this ends the matter. If, however, a 'set' is obtained, and star-fish make their appearance and an unsuccessful attempt is made to rid the bed of the star-fish the cost of this work must of course be added in order to give the total loss. In this way, Mr. Jeremiah Smith lost in 1884, on a bed of 250 acres off Milford, the cost of planting—over $11,000. Seventy-five thousand bushels of shells had been put on the bed, and the cost of sets was obtained. It was soon discovered, however, that minute star-fish were almost as thick upon the shells as oyster spat, and in a few weeks all the young oysters had been destroyed. So complete and rapid was

the work of the little star-fish that the whole bed was abandoned. Other men prefer to estimate their loss from star-fish by the cost of fighting them. The cost of running a dredging steamer may be put at from $30 to $35 per day. This has come to be an important item of cost in the raising of oysters. Landcraft Bros. expend yearly from $3,000 to $10,000 in fighting star-fish alone. Smith & Sons, New Haven, expend yearly about $6,000 for the protection of 1,200 acres of ground. Mr. W. W. Law, also of New Haven, spent $2,000 in fighting star-fish in 1888. The above are given merely as specimen estimates. If any general estimate of the amount of harm done by starfish in Long Island Sound is to be made, it must be done by some other method than off-hand inquiry. Most of the oyster growers whom I interviewed were not prepared to give any such estimate." Similar conditions obtain in Rhode Island, and oyster planters say that were it not for the star-fish, oysters would sell in the market for one-third of their present price.

The general external appearance of the star-fish is familiar to nearly every one. Low tide frequently leaves them exposed, when they are too pre-occupied in sucking an oyster or barnacle, on the rocks or on the piles of wharves. Usually they crawl slowly about on the bottom, with the whiter or mouth side down, moving by means of thousands of tiny legs, four rows extending lengthwise of each arm. Each leg ends in a disc which acts upon the principle of the boys' leathern sucker and does its part in holding the animal to the bottom.

It is perhaps scarcely within the scope of the present writing to enter into the interesting anatomical details, or to go minutely into the complicated structure of the organs and the remarkable physiological processes displayed. Sufficient to mention that from the central portion or disc radiate the arms (compare Fig. 32), usually five (but frequently six or even more), which are freely movable and pliable, especially when under the control of the animal's own muscles, though incapable of rapid motion. Along the center of the groove on the under side runs the radial nerve

cord, a thickening and modification of the skin, ending at the tip of each ray in a very small red spot of pigment, which seems to function to some extent as an eye. (The error is frequent of regarding the conspicuous reddish yellow spot on the upper side as the eye.) (Compare Fig. 29.) Above and parallel to each nerve cord is a minute tube which sends off branches to the rows of feet, which are seemingly two rows on either side. (Closer acquaintance shows that the arrangement is of a single zigzag row on each side.) These feet pierce the walls of the groove between the plates which compose it; in connection with each foot and on the floor of the interior of the arm is a small bladder-like body, very small when the foot is extended, but larger when the foot is contracted.

WHY AND HOW DOES THE STAR-FISH TRAVEL?

Experiments demonstrate that the star-fish has rather acute sensations, and that the actions resulting from these sensations are nearly, if not quite, identical with those of the higher animals. For example, if food be placed in the water near a hungry star-fish, he will travel directly towards it as soon as the odor reaches his sense organs. The physiology of the process is as follows: tiny odorous particles strike against the sensory cells of the organ of smell, from this sense organ a stimulus travels to certain of the cells which make up the central nervous system. Here the sensory impulse is changed (we neither know how nor the nature of this change) into an impulse which travels in the nerves leading to the muscles, particularly to those which control the feet. The result is that the creature begins to crawl directly toward the food. Locomotion is effected by alternate and repeated extension of the feet, followed by fixation by the in-sucking discs to some firm object on the bottom, and finally, by contraction of the muscles of the tubular feet, the entire body is drawn forward. Most remarkable is the degree of co-ordination exhibited: those feet which are behind let go at the proper moment, so that the onward progress is not checked.

Having reached its prey the star-fish crawls over it and envelops it in the manner shown in Plate I. From the mouth, located in the center of the under side, a yellowish veil-like substance (the walls of the stomach) is slowly protruded, which ultimately wraps itself almost completely around the prey. This protruded portion is the wall of the stomach, and digestion now begins. The prey, dead or living, rapidly diminishes in size, and in a short time only the indigestible portion remains. The starfish then pulls in his stomach by means of special muscles properly attached for that purpose, not however with a full stomach as we are accustomed to use the term, but yet in possession of all the nutriment to be derived from a bulk of food which may even exceed his own weight. Thus it is seen that he has enormous gormandizing capacities, and the astonishing facility with which he dispatches meal after meal shows that indigestion has not yet spread to star-fishdom, and that devastation must come to the oyster beds unless his career is stopped.

If we cut away the upper surface of the star-fish we see that the interior is almost completely filled by a soft greenish or brownish mass. Careful dissection under water will show that delicate tubes lead from each of these masses and conduct the fluid there secreted into the stomach. Investigation has shown that these masses are digestive glands, and that they secrete a fluid which shows many of the properties exhibited by the bile and by the pancreatic juice of the higher animals. These glands, therefore, are to be regarded not as a "liver," as is frequently done, but as a liver and a pancreas combined.

In addition to the digestive glands the interior of each arm contains two sexual glands, opening separately on either side of the apex of the angle between the arms. The eggs and spermatozoa are produced in different individuals. The female sexual glands or ovaries, when distended with eggs (in May and June), are distinctly of a salmon-pink color, while in the males the sexual glands (testes) are greyish white.

The central portion of the star-fish (the "disc"), from which the

arms radiate, contains the much-folded, thin-walled stomach, into which, on the lower side, the mouth leads, and from which runs upwards a very short intestine opening to the exterior in the center of the upper surface by a very tiny pore, the anus. Within the disc also are certain organs whose anatomy is obscure and whose function is unknown. Probably the most conspicuous feature on the upper external surface is the yellow or orange colored spot directly opposite the apex of one of the angles. It is seen near the upper left hand edge of the feeding star-fish shown in Plate I, and again in Figs. 29 and 32. Though commonly called "the eye," it has not a single characteristic of an eye. (It will be remembered that the eyes are located at the tip of each arm, on the end of each radial nerve.) If examined with a magnifying glass the rounded surface will be seen to be marked with lines and holes, so that its function can be suspected from its appearance. It is in reality a sieve through which the water enters a limestone tube, whence it passes into a circular canal surrounding the mouth; from this circular canal it enters the five radial canals, where it does the hydraulic work for moving the animal.

Lack of space permits merely a passing reference to the wonderful cells which pick up the waste substances within the body, and, by burrowing through the skin, carry these waste substances (usually in the form of microscopic colored granules) to the surface, where they serve for giving to the animal those colors so closely imitating his surroundings that the eyes of many enemies are deceived.

LIFE HISTORY.

The details of the star-fish's life from the egg to maturity present changes of wonderful complexity. Changes of a similar nature are seen in the life of the butterflies, where the egg hatches into a caterpillar, which after a time changes into a butterfly. So, too, the egg of the star-fish hatches not into a star-fish, but into an animal so different that the relationship was for many years unsuspected, and these various stages in the development of the same

animal were given different names; the names Bi-pin-ná-ria and Brach-i-o-lár-ia, still given to the immature or larval stage of the star-fish, originated in this way. (Compare Plate IV and Plate V, Figs. 15 to 20.)

The eggs are discharged into the water through the ten genital openings, in the early summer, in greatest numbers in this latitude in May and June. The eggs are very small but can be readily seen by the trained eye. The spermatozoa, however, which are discharged by the males in a similar manner, can be seen only under a high power of the microscope. During the process of discharge the appearance is of one or more tiny streams of white opaque fluid, which at a short distance spreads out into a milky cloudiness and rapidly fades away as the spermatozoa are scattered. The eggs and spermatozoa are borne about by currents, and within a few hours, through the agency of certain chemical properties peculiar to the substance of the egg and spermatozoon, they are drawn towards each other until they meet. The sperm (Plate II, Fig. 1), by active sculling motions of its tail bores into the egg (Plate II, Fig. 3), and then begins a progressive series of changes which will ultimately result in a new individual like its parents. Omitting certain features in the development, which go on during the first hour after the penetration of the spermatozoon and can be observed only by trained eyes, after complicated treatment of the egg with special chemicals, the first marked change is the division of the egg into two similar parts, or cells (see Plate II Fig. 4). After about fifteen minutes each of these cells divides into two, making four in all. This process continues at intervals, forming successively 8, 16, 32, 64, 128, 256, etc. (several stages in the process are shown in Figs. 5, 6 and 7), until ten or twelve hours after fertilization the very much smaller cells have arranged themselves around a central spherical area which is filled with a thin, colorless, gelatinous fluid. (Plate III, Fig. 8.) The condition at this stage may be understood by comparing it to a hollow rubber ball. Soon motions can be observed; this motion increases until the creature is spinning rapidly within the egg membrane, through

the action of tiny vibratile hair-like projections on each cell. The rotary motion soon wears through the membrane, and the animal escapes (*i. e.*, hatches) and rises to the surface of the water. From that point the changes become more complicated and can best be understood through close attention to the drawings. (Figs. 8 to 24.) Even at the time of hatching a few cells in one region begin to travel inward (Fig. 8), soon the migration becomes more general (Fig. 9), and finally all the cells of that region push inward, thus forming an indentation (Fig. 10). This indentation rapidly pushes farther into the cavity, until the condition shown in Fig. 11 is reached. The internal cavity thus formed becomes the stomach and intestine of the larva, and, after the transformation, or metamorphosis, it performs the same office for the adult star-fish. It is to be noted that the star-fish hatches as soon as the stomach begins to be formed, so that almost from birth the animal is self-supporting. Near the blind end of this stomach region two minute, bladder-like structures are pushed out, right and left (Fig. 12). With the growth of the animal these increase in size. Their development may be traced through Figs. 12, 15, 16, 19, el. In the adult the right becomes a part of the lining of the so-called "body cavity." The left divides: one portion completes the lining of the "body cavity," the remainder becomes the vessels of the water system (the circular canal around the mouth, and the radiating canals, with the rows of feet, and the vesicles connected with them.)

The original entrance to the primitive stomach becomes gradually smaller and becomes the anus of the larva (Figs. 11, 13, and 14 bl). The small tube leading from the stomach to the anus is the intestine. The mouth is formed in a somewhat complicated manner. New cells begin to bud out on the wall of the stomach, forming a bunch which extends outwards towards the surface of the body. (Fig. 13*m*.) On the inner wall of the body, too, the cells multiply and form a mass which projects inwards towards the stomach. These two masses of cells increase and finally meet, and in the interior a canal is formed which connects the stomach

with the exterior; the external opening is the mouth, the canal is the gullet or œ-soph-a-gus. (Plate IV, Fig. 17.)

With the completion of the mouth the creature has the appearance shown in Plate III, Fig. 14. The tiny hairs (cilia) which covered the entire body at the time of hatching have now disappeared, except over certain lines (Fig. 14, c. o. b.). It is by means of the movements of the cilia on these lines that the animal moves slowly through the water.

The general shape of the body now undergoes a gradual change, due chiefly to outgrowths along these ciliated lines. Some of the more characteristic changes are shown progressively in Plate IV, Figs. 15, 16, 17 and 18; Plate V, 19 and 20. Figs. 15 to 19 are of the stages known as the Bipinnaria, while Fig. 20 shows a Brachiolaria.

When arrived at these conditions the creature, or larva, begins to show conspicuous indications of an approaching change. Near the posterior end (the lower end in Fig. 20) appears an opaque area, which betokens the young star-fish. With the growth of the young star-fish the larva becomes gradually smaller, the larval tissues being in the main absorbed by the star-fish proper (Plate V, Fig. 21). The star-fish soon acquires its characteristic shape, though minus the 5 long rays. With the complete disappearance of the larva (as shown in Plate V, Figs. 21, 22, 23 and 24) the animal becomes rapidly heavier and settles towards the bottom, at length resting upon some support. The appearance at this stage is shown in dorsal (*i. e.* upper) view by Fig. 24 and in ventral (*i. e.* lower or mouth side) view by Fig. 25. The dark pouches (Fig. 25) are the growing feet. A little older condition is shown in side view, Plate VI, Fig. 26, and a still later stage in dorsal view in Fig. 27, where the young star-fish has attained practically all the characteristics of the adult, except size and sexual maturity. For a short time these tiny star-fishes remain attached, often in great numbers, on the eel-grass and other sea-weeds just below low water mark along the shore and on the piles of wharves, but later they wander out and begin their marauding career.

The star-fish seems to have few enemies after becoming adult. The immense number of eggs (computed by Hodge from a specimen 6 inches in diameter to be 30,719,377) at a single laying indicates that the mortality of eggs and larvæ is very great. The free swimming stages serve as important food for small crustacea and fishes during the months of June, July and August. The small "stars" fall a prey to bottom-feeding fish and crabs, and, according to some observers, to certain marine snails (*Urosalpinx cinerea* and others). The adults are eaten by large fish. Under certain conditions, scarcity of food, etc., the "five-finger" turns cannibal. The writer has seen evidences of epidemic disease among certain related species. Like other creatures, they are not free from parasitic animals and plants; some attacking the digestive system, and others feeding upon various portions of the body, *e. g.*, a multicellular alga flourishing in the reproductive glands to such an extent as to destroy their function.

From the fact that the young or larval star-fish swims freely in the water it is readily seen that the question of dealing with the pest presents unusual difficulties. But there is another phase which still further complicates matters. In destroying most animals it is sufficient to deal a fatal blow; but a mechanical injury, ordinarily fatal to most animals, passes unheeded in the star-fish; even worse, a "five-finger" violently torn in two, literally "drawn and quartered," has the capacity of growing again the parts lacking to each piece and thus becoming (within certain limits) not one but several complete star-fish. Plate VII shows photographs of various types of regeneration of lost parts. Other species of star-fish have greater capacity for such regeneration, *e. g.*, *Linckia*, a tropical species, may regenerate a whole star-fish from apparently a single arm, though probably even here there are left with the arm some of the cells of the disc.

This capacity of star-fish fragments of building themselves into complete animals again would seem to indicate remarkable vitality. But this vitality seems effective only in case of mechanical injuries, and, strangely enough, the "five-fingers" are extraor-

dinarily susceptible to chemical changes and alterations of temperature. A sudden change in the specific gravity of the waters as when freshet waters diminish the saltness of the bays, either drives the star-fish out into the salter water or kills them. The writer saw enormous numbers of star-fish below Field's Point, killed by the great freshet of 1886, on the then extensive oyster beds off Starvegoat Island, Narragansett Bay.

The magnitude of the star-fish evil, while mainly known only to the direct sufferers, has attracted the attention of those who are after all most deeply interested, and upon whom indirectly the burden of destroying the five-fingers falls. The poor wage earner, who pays for oysters stewed or fried, is forced to pay for those oysters two or three times as much as he would if the oyster growers were not compelled to incur the annually increasing expense of keeping the oyster beds free from the "five-fingers."

Wherein lies the remedy? First of all, oysters, clams and mussels grow well in water which is too brackish for star-fish. Hence every such area should be utilized for growing these bivalves, since these areas are free from the greatest enemy of oysters and mussels, and should not be permitted to remain wastefully idle or even to yield less than their full capacity. Artificial conditions should never be allowed to injure such areas, for they are far more valuable than an equal area of land above water. From the nature of the locomotory apparatus it would seem that starfish cannot travel over deep soft mud. Hence barriers or areas of such mud might prevent the ingress of migrating adults, though of course it would do nothing towards preventing the floating larvæ from settling on the beds.

Further, fishermen should be instructed in regard to the habits and life-history of the "five-finger" in order to teach them to deal intelligently with the question. But beyond that, a law should be enacted by this and other States requiring that all "five-fingers" caught should be brought ashore or kept until dead. This will do much to aid those who spend time and money to free their own shell-fish beds from "five-fingers," when at the same time the owners of

neighboring beds do nothing to assist in the work which is of common benefit. Plate VIII, Figs. 34 and 35, show the device for mopping the beds. The star-fish are entangled in the bunches of cotton-waste, hemp, etc.

But much more effective than any law is the dissemination of the knowledge that the star-fish has a considerable commercial value, and that every bushel thrown overboard or permitted to decay is so much money actually wasted. For ordinarily the "five-fingers" are caught in the same dredge with the oysters and scallops, and little extra labor or time is required to bring them ashore, and fifty cents or a dollar per day additional for the "five-fingers" caught incidentally cannot fail to be of practical interest to the fisherman, while the oyster dealer, who spends thousands of dollars annually in fighting the starfish, would get a return on part at least of the expense through the sale of the tons of "five-fingers" brought in and destroyed.

Figures showing the number of pounds of star-fish caught by the Stratford Oyster Co. from 1892 to 1897, inclusive. This company is to be congratulated on the careful records which have already, in several instances, furnished valuable data on the star-fish question.

	1892. lbs.	1893. lbs.	1894. lbs.	1895. lbs.	1896. lbs.	1897. lbs.	
January......	....	676	1,927	3,185	12,092	18,469	...January.
February.....	1,752	586	1,403	1,181	1,973	4,662	...February.
March	4,537	260	603	1,120	1,161	1,012	...March.
April.........	3,721	220	823	74	328	393	...April.
May	2,145	239	1,594	100	2,278	1,213	...May.
June	3,639	6,543	1,504	967	1,586	38,156	...June.
July...	15,467	17,134	2,342	13,314	10,706	11,052	...July.
August	612	3,150	3,909	3,081	4,540	3,048	...August.
September....	730	706	1,966	2,459	1,574	60	..September.
October......	3,316	1,358	3,849	7,762	10,936	28,882	...October.
November....	2,532	4,600	3,276	15,968	16,694	15,613	...November.
December....	3,536	3,400	6,055	14,477	15,971	8,900	...December.
Total.....	41,987	38,872	29,251	63,688	79,839	131,460	

The tables indicate but vaguely the number of star-fish which are annually taken from Long Island Sound and Narragansett Bay, since these show merely those caught by a single firm of oyster dealers. The actual amount caught annually is certainly ten times this quantity, or, at a very conservative estimate, 1,000 tons annually, whose value is at least $5 per ton. By far the greatest portion is wasted. It should be noted that the figures of the quantities of star-fish caught show a rapid increase (with the exception of the years 1893–94), from 41,987 pounds to 131,460 pounds.

The figures of the one firm are given as typical of the experience of at least 200 different oyster growers on the southern shores of New England.

ANALYSES OF STAR-FISHES.

In order to get the actual commercial value of star-fish as a practical fertilizer, a careful chemical analysis has been made by the Chemical Division of the Experiment Station.

	Calculated to live unrinsed fishes as received.	Calculated to absolutely dry star-fishes rinsed with fresh water before drying.
	Per cent.	Per cent.
Loss by rinsing with fresh water and complete drying	65.43	.....
Crude ash	20.34	58.84
Lime (calcium oxid)	9.62	27.82
Potash (potassium oxid)	.23	.66
Phosphoric acid (P_2O_5)	20	.57
Nitrogen	1.80	5.20
Insoluble matter	.34	.97

The quantities of soda, magnesia and certain other ingredients were not determined.

Estimating the lime at .421 of a cent, potash at 4¼ cents, phosphoric acid at 5 cents and nitrogen at 13 cents per pound, which are the approximate retail prices in Providence, the star-fish, as

taken from the water, have a value of 29½ cents per 100 pounds, and, after rinsing and complete drying, a value of 85 cents per 100 pounds.

It is intended to carry on at the State Agricultural Experiment Station definite experiments to determine actual manurial value of star-fish for various crops, both alone (whole, dried and pulverized) and where mixed with other chemical plant foods.

In regard to the practical question as to the advisability of placing a bounty on star-fish: it would seem as if the demonstration of the fact that star-fish are worth for fertilizing purposes .27½ per 100 lbs., delivered on the wharf, should be incentive enough to the fishermen, especially when taken in connection with the fact that every star-fish destroyed is of direct benefit to those dependent upon the shell fisheries; still, if for special reasons it should seem fitting to place such a bounty, the basis should be, for convenience, per hundred weight rather than per bushel.

EXPLANATION OF PLATES ILLUSTRATING THE LIFE HISTORY OF THE STAR-FISH.

Figs. 2; 6; to 10, and 14 to 19 are from previous work of the writer, published in Quarterly Journal of Microscopical Science, Vol. 34. London, England.

Figs. 20 to 28 are from A. Agassiz's Embryology of the Star-fish.

PLATE I. A STAR-FISH DEVOURING AN OYSTER.

PLATE II.

Fig. 1. The male sexual cell (spermatozoon) of star-fish x 1500.

Fig. 2. Section through the ripe ovary. Only ¼ of the section is drawn. Shows the mode of origin of the eggs from the cell layer on the external wall (*g.e.*).

Fig. 3. The ripe, freshly laid egg, before fertilization.

Fig. 4. Condition at the end of the first stage of the cleavage process. The egg has divided into two cells.

Figs. 5, 6 and 7. Showing the results of the continuance of the cleavage process, binary division resulting in 4, 8, 16 etc., cells.

PLATE III. (N. B. Figs. 8–13 represent optical sections.)

Fig. 8. Condition at end of cleavage process; a hollow sphere bounded by a single layer of small cells. Five cells at the periphery are repre-

sented as pushing out into the central cavity, thus to form the middle layer of the body.

Fig. 9. The beginning of the formation of the stomach.

Fig. 10. One side is pushed farther towards the center, the cavity thus formed (*ar*) becomes the stomach.

Fig. 11. Represents the condition at the time of completion of the primitive stomach. The external (*bl*) opening into the stomach (*ar*) becomes the anus.

Fig. 12. The formation of the body cavities (*el*).

Fig. 13. The same seen at right angles to position shown in Fig. 12, to show the beginning of the formation of the mouth; a mass of cells (*m*) grows inwards and meets a similar outgrowth from the wall of the stomach; at first solid, it later forms a tube, the gullet. See Fig. 14 (*oe*).

Fig. 14. The young free-swimming larva, seen from the mouth side. The the tiny hairs (*cilia*) which originally covered the entire surface have disappeared, except over certain lines as shown at *c. o. b.* & *a. o. b.* The cilia on these lines serve as swimming organs for the larva. The digestive system is now complete, the mouth (*mo*) œsophagus (gullet) (*oe*), stomach (*sh*), from which the intestine passes, opening to the exterior at the anus (*bl*).

PLATE IV.

Fig. 15. A larva about 3 days old, seen from the dorsal side, much more magnified than Fig. 14. (*El*) body cavities; (*w. p*) their openings to the exterior; (*a. p*) the apical pole and sense organ; (*c. o. b*) one of the ciliated bands; (*mm*) primitive muscle cells.

Fig. 16. A larva (Bipinnaria) about 20 days old, seen from the dorsal side. (*a*) anterior, (*p*) posterior; (*c. o. b.*) ciliated band; (*el.*) body cavity; (*oe.*) œsophagus; (*sh.*) stomach; (*w. p.*) water pore.

Fig. 17. Young larva like that shown in Fig. 15, but seen in side view. Lettering as in previous figures.

Fig. 18. A (Bipinnaria) larva about 18 days old, seen from the ventral side; (*c. o. b. and a. o. b.*) ciliated bands; (*int.*) intestine; (*an.*) anus. Other letters as above.

PLATE V.

Fig. 19. Larva (Bipinnaria) about 35 days old, in ventral view. E 1 to 6 indicates the projections or "arms" of the larva, due to a lengthening of the ciliated bands; (*mo*) mouth. Other letters as above.

Fig. 20. Adult larva (Brachiolaria) seen in ventral view. At the lower

PLATE I. Star fish eating oyster.

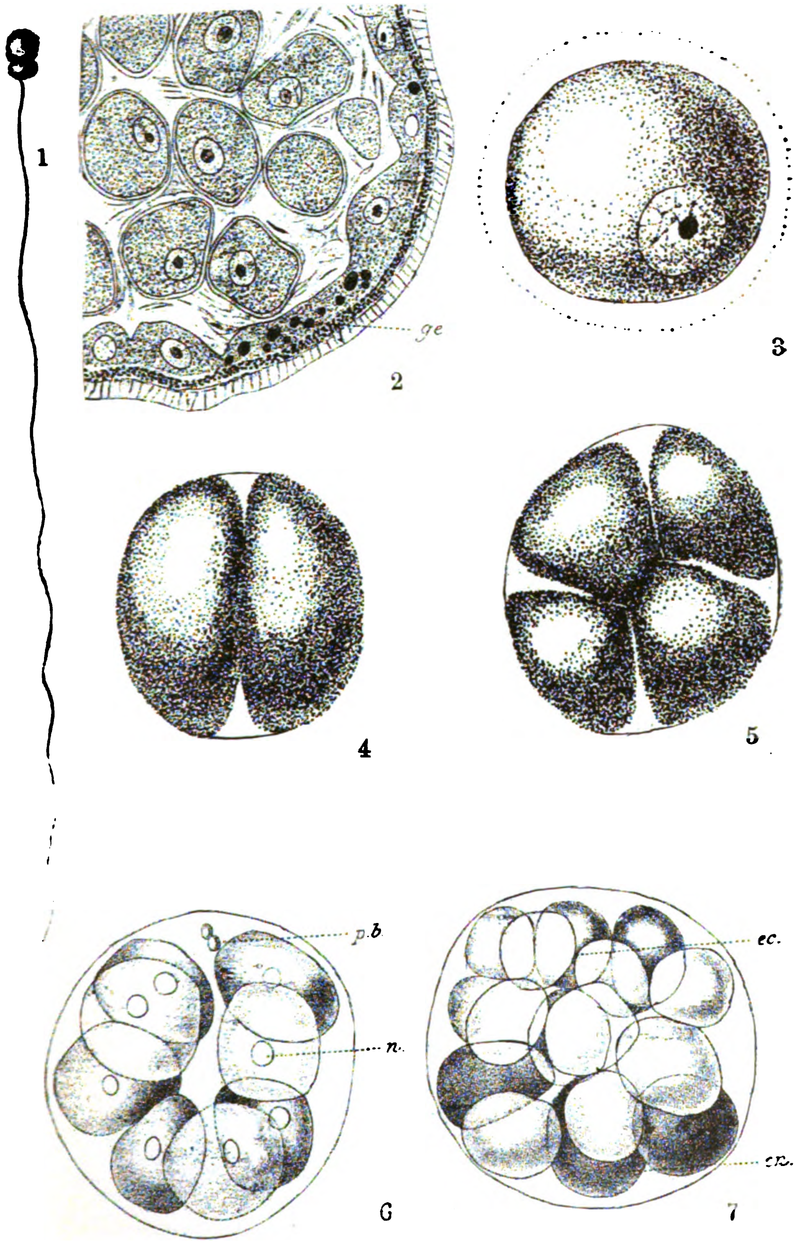

PLATE II.

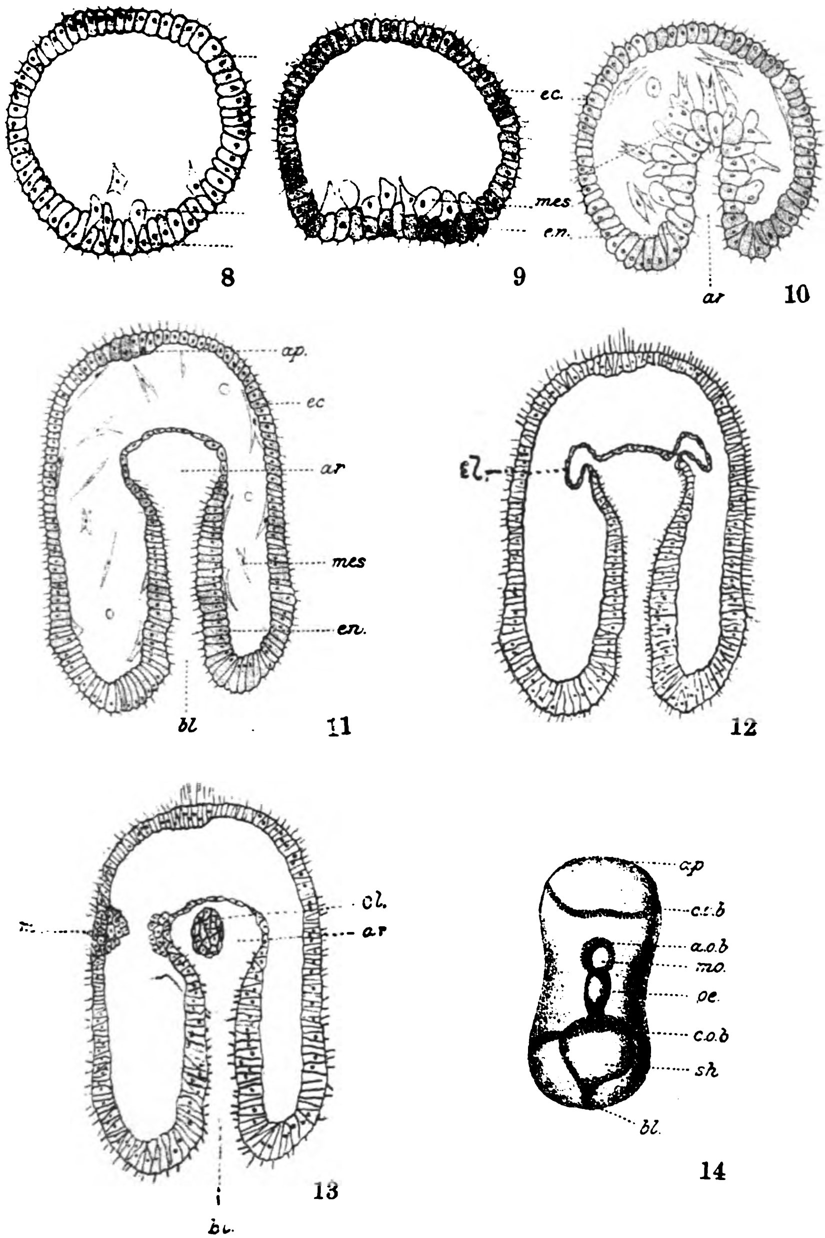
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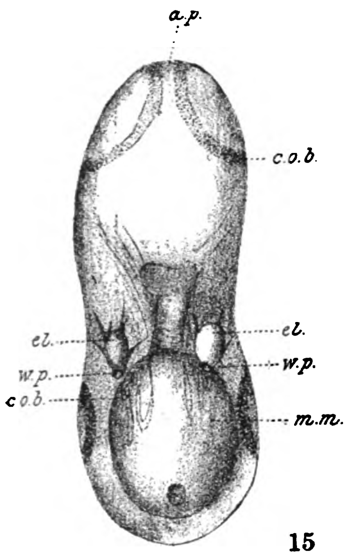
PLATE III.



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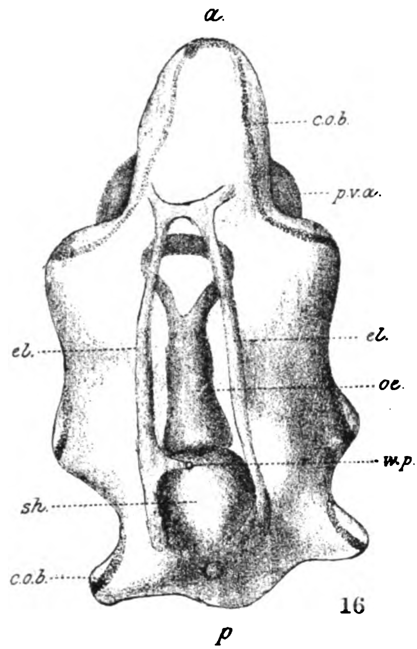

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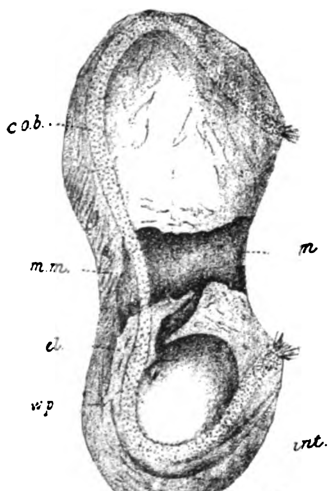

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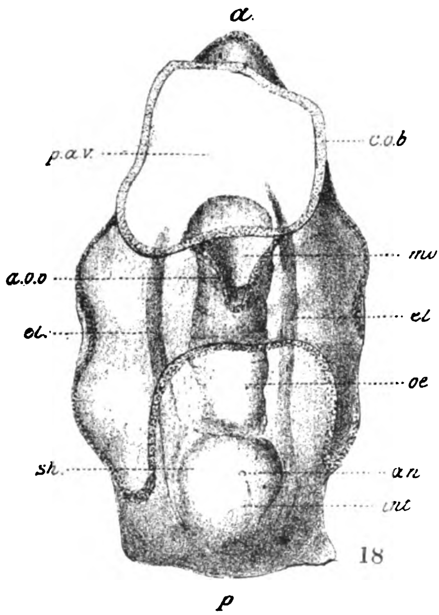

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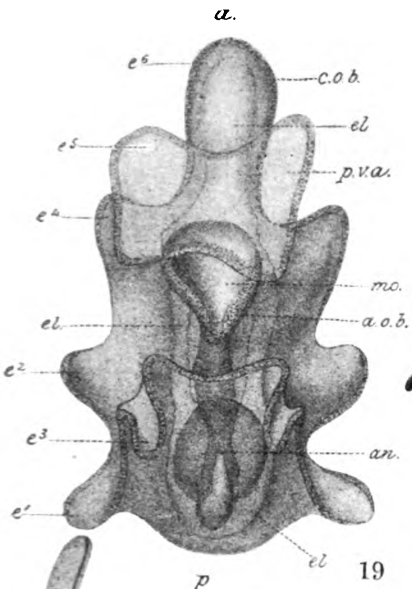
Plate IV.



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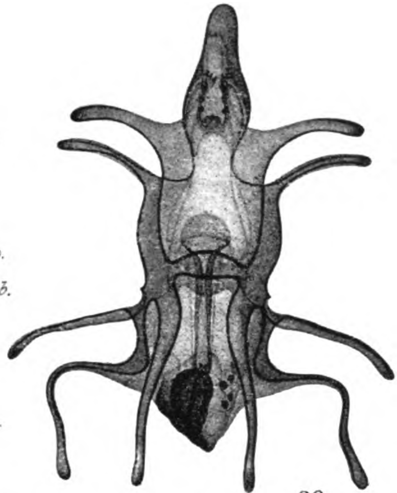

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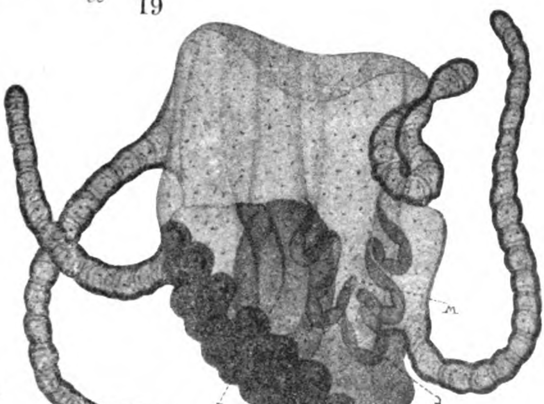

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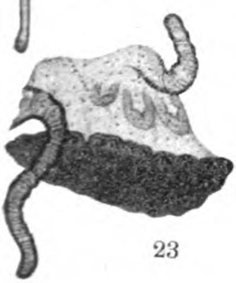

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PLATE V.

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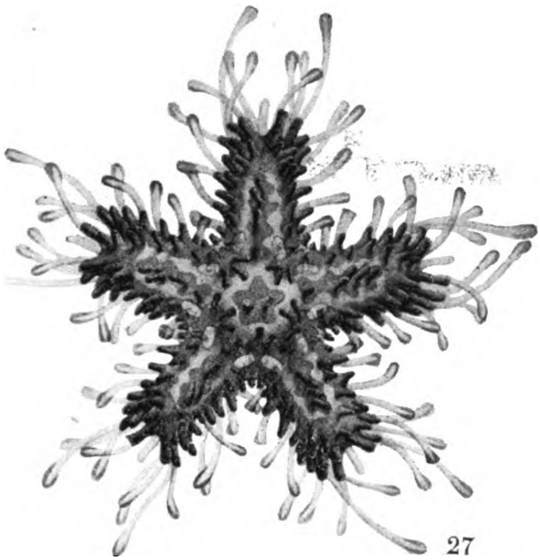

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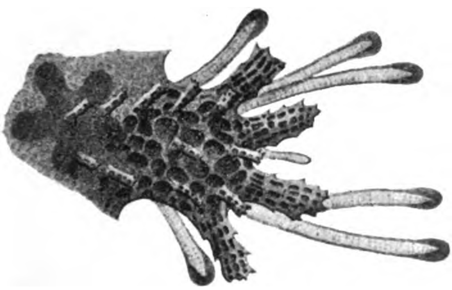

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PLATE VI.

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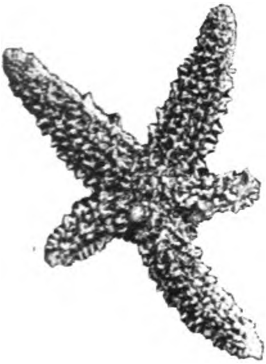

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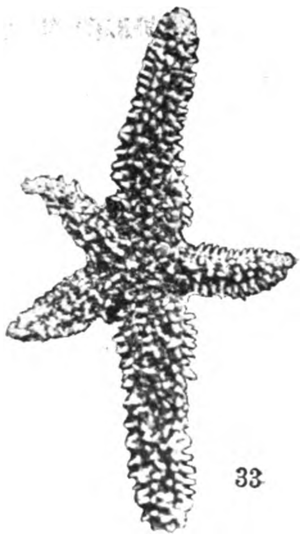

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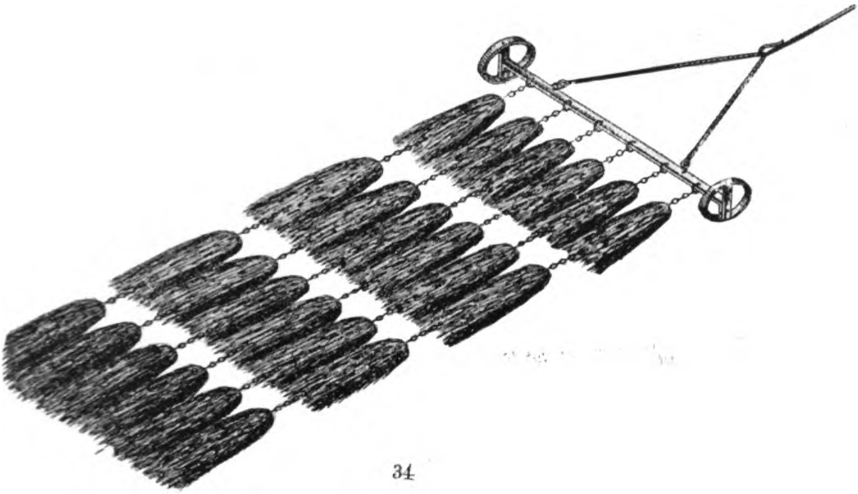
PLATE VII.



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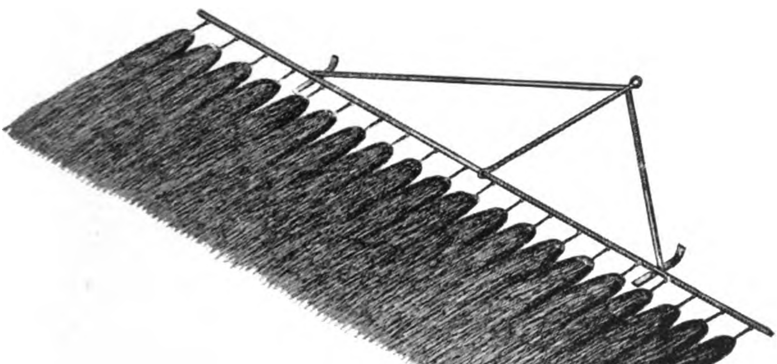

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Plate VIII.

end is seen the beginning of the young star-fish. (Figures 20 to 28 inclusive are from Prof. A. Agassiz.)

Figs. 21, 22 and 23. Show the progressive growth of the star-fish and the absorption of the larva.

Figs. 24 and 25. Dorsal and ventral views of the very young star-fish after the absorption of the larva.

PLATE VI.

Fig. 26. Star-fish a few days later, after the formation of the legs. Seen in side view.

Fig. 27. Same in dorsal view.

Fig. 28. Tip of ray ("finger") showing the lime-stone plates in the dorsal surface, with the spines (*P*); (*t*) tentacles or terminal legs.

PLATE VII.

Fig. 29. An adult star-fish which has lost three rays. The disc has healed.

Figs. 30-33. Show stages in the process of regeneration of lost rays.

PLATE VIII.

Figs. 34 and 35. "Mops," or "tangles" for catching star-fish. An iron framework with dependent bunches of tow or cotton waste, which is dragged over the oyster beds. (From drawings by D. C. Sanford.)

CHEMICAL DIVISION.

H. J. WHEELER.

On account of the fact that the chemical division is involved in several lines of work, no better idea can be given of what is being done than by discussing each feature of the work by itself.

FERTILIZER INSPECTION.

During the winter circular letters were sent to farmers in various sections of the State, for the purpose of ascertaining at what prices fertilizer stock had been offered for sale at retail within the State. These and similar quotations obtained by a number of other stations, together with wholesale quotations given in trade journals, were employed as a basis for fixing a schedule of prices to be used in the valuation of fertilizers for 1897. The station chemist attended the convention held in New Haven, Conn., for the purpose of comparing prices and adopting such a schedule. Prior to April 1st notices were sent to all fertilizer manufacturers doing business in Rhode Island, calling their attention to the fact that the fees due in connection with the fertilizer inspection were payable on or before April 1. For over a month a deputy was traveling about the State collecting samples of such fertilizing materials as were being sold, offered or exposed for sale, in Rhode Island. The work of analyzing these materials continued without interruption until about June 1st, when a notification was received by the Director of the Station from the Secretary of the State Board of Agriculture, to the effect that a change in the law had

been effected by which all matters pertaining to the fertilizer inspection in the State had been transferred to that body. Thereupon the work was discontinued. At the time the work was thus unexpectedly interrupted, a bulletin was ready for the printer, which it was intended to have issued to the farmers of the State by the middle of June. The analytical data were turned over to the Secretary of the State Board of Agriculture, and published as Bulletin No. I, of the State Board of Agriculture. It was not mentioned that the work had been done at this Station. Bids for analyzing the fertilizers for the State Board of Agriculture were subsequently called for, and this Station, by authority of the Board of Managers, made bids as low as it could, consistently, without lowering the character or volume of the chemical work. These bids also included the publication of the bulletins as heretofore, and were so made for the reason that the Station could do that work more economically than the State Board of Agriculture, by reason of the fact that it enjoyed a franking privilege from the Government under which the bulletins could be distributed without cost for postage. Owing to the rejection of the Station bids the work of fertilizer inspection passed entirely out of the hands of the Station.

Early in the year 1897 circular letters were sent to those interested in the fertilizer inspection in the New England States, New York, Pennsylvania, New Jersey, Maryland, and also to the Secretary of Agriculture at Washington, asking if it was deemed advisable to set on foot a movement to secure, if possible, a greater degree of uniformity in the fertilizer laws of the several States. This lack of uniformity causes endless trouble to manufacturers as well as to those who have in charge the work of inspection. As expected, the replies received were practically unanimous in favor of such a step. Accordingly a convention, for the purpose of taking action in this line, was called to meet in New Haven, Conn., immediately at the close of the meeting for fixing a schedule of prices for fertilizer valuations. The matter was brought, in due form, before the State Board of Agriculture at

its winter meeting, and Mr. H. W. Potter, of that Board, was appointed as a delegate of that body to the New Haven meeting. At the meeting a committee of five, of which the chemist of this Station was made chairman, was appointed to further investigate the matter. In accordance with these instructions a committee meeting was called in New York, in May, at which the chairman presented letters in relation to the matter from fertilizer companies in all parts of the United States and also from the official chemists of the country. Several conferences were held, and a hearing given to a committee appointed for the purpose by an association of fertilizer manufacturers. It was the opinion of the committee that, in order that the movement might secure an official endorsement, a report should be made to the Association of American Agricultural Colleges and Experiment Stations and to the Association of Official Agricultural Chemists, with the suggestion that the presidents of the two associations confer and appoint a joint committee, or that each appoint separate committees, to act in concert in furtherance of the plan of unification. Two such committees were subsequently appointed, in whose hands the matter was left for further action.

METHODS OF ANALYSIS.

Such work as it was possible to undertake, in response to the calls of the reporters of the Association of Official Agricultural Chemists, was done in the line of testing and further perfecting the methods of analysis for use by the association. At its meeting a chart was exhibited, and the work of this division, in testing the comparative reliability of different chemical methods of arriving at the probable need of liming various Rhode Island soils, was explained.

SPECIAL CHEMICAL INVESTIGATIONS.

Investigations in relation to the action of lime upon the humus content of soils and upon the percentage of nitrogen in the

humus have been continued. Further tests have also been made for the purpose of comparing various methods of ascertaining the degree of acidity of soils. Material for this purpose has been obtained from the small experiment plots located in various sections of the State.

Comparative ash analyses have been made of several plants which had been grown in connection with alkaline substances of various kinds, for the purpose of obtaining further light upon the probable degree of their action as correctives of soil acidity or as manures. Some of the results are highly instructive and may lead to new lines of work of value in the study of the needs of our Rhode Island soils.

Many special determinations of nitrogen, phosphoric acid, potash and soda have been and are being made in plants grown in connection with the pot and field experiments, for without the light which such examinations throw upon the experimental results a good share of the time and expense involved in the work of experimenting would be wasted.

It is to be hoped that better opportunities for the prosecution of this work will be afforded in the future than heretofore.

FIELD EXPERIMENTS.

The field experiments in which the chemical division has had a part have consisted of a continuation of the observations in connection with soil tests with different plants and under varying conditions, also a further study of the action of lime upon the growth of various plants, with special reference to small fruits, grapes, orchard fruits and forest trees, and a continuation of the experiments on the substitution for, and the value of soda in connection with potash.

Many of the small plot experiments begun in 1896, in various sections of the State, have been continued this season, and show in a most striking manner that many of our Rhode Island soils are too poor in carbonate of lime, and, consequently, too acid to produce

timothy and clover to good advantage. Other experiments, with beets, undertaken the past season, corroborate fully the idea that a widespread deficiency of lime exists in Rhode Island. In view of the thousands of acres of land probably in need of liming for the reclamation of which stable manure is unobtainable, or, if at all, at too great an expense to make its use feasible, it would seem that a study of the lime question, and of the most economical forms of chemical manures to use in connection with it, promises much for the agriculture of the State, if our farmers will but give it the attention it deserves. By this it is not meant that every farmer should begin to use lime blindly, but that an experiment with beets or timothy, or, better, with beets followed by timothy, should be made upon every farm to ascertain if lime is needed, and then act accordingly.

POT EXPERIMENTS.

Prior to 1897 the pot experiments which had been undertaken were conducted almost wholly in large galvanized iron pots, sunk in the ground to within two inches of their tops, and then filled till the soil within was on a level with that without. The plants in these pots were exposed to all the inclemencies of the weather, which utterly precluded the successful conduct of certain lines of experimental work, though, for some experiments, these pots serve a very useful purpose. In order to enlarge the scope of the vegetation experiments, and to pursue studies in lines which had been precluded heretofore, a glass house, for summer experiments, equipped with transfer trucks for carrying the plants into the open air during pleasant weather, was erected during the early spring. The planning and working out of all the many details of the various experiments in this line have occupied much time.

EXPERIMENTS IN CULTURE UNDER GLASS.

The care of the small greenhouse having passed into the hands of the professor of agriculture at the college it was placed at the

disposal of this division for the purpose of making some preliminary trials of different manurial combinations for inside work. The house is extremely small, and in a condition practically beyond repair, and is also illy adapted to such work, yet the experiments in progress indicate that this line of investigation is full of promise, and could be made extremely useful if sufficient means were provided to erect a practical house suited to such needs. If such a house were available, experiments of much practical value could be conducted, and the boarding department of the college could incidentally be supplied at limited cost with certain vegetables, which are now unobtainable here at moderate rates.

LABORATORY FACILITIES.

Since the completion of Lippitt Hall the chemical work of the college has been transferred from the Station laboratory building to other and more commodious quarters elsewhere, so that both of the wings of the laboratory stand at the disposal of this division. Before the vacated portion of the building is suitable for occupancy as a working chemical laboratory the heating facilities should be enlarged, and properly ventilated hoods provided in order to free it from poisonous and noxious vapors.

CORRESPONDENCE AND PUBLICATIONS.

The correspondence has been much increased the past season, owing to the movement to secure uniform legislation in relation to the inspection and control of the sale of commercial fertilizers. The removal of the work of fertilizer inspection from the Station lessened the work in that connection somewhat, though the chief part of the correspondence for the year had already been attended to before the transfer was effected. As stated elsewhere in this report, Bulletin No. 1, issued by the State Board of Agriculture was almost entirely, if not wholly, the work of this division: the only other publication by the division has been that of Bulletin 46, on Lime and Liming.

ACKNOWLEDGMENTS.

I desire in this connection to thank those farmers about the State, who have cared for the coöperative experimental plots, for their efforts in assisting in experimental work for the good of the farmers of the State at large. It is a most commendable feature, and an encouragement to those connected with this Station, that the farmers of the State stand ready to thus coöperate for the common good.

Owing to the resignation of Mr. George M. Tucker, who withdrew from the Station for the purpose of pursuing the further study of agriculture at a German university, Mr. Joseph A. Tillinghast, of Summit, R. I., was engaged to take charge of the details connected with the field experiments. His exact business methods and wide experience as a practical farmer, coupled with a knowledge of the chemistry of manures, peculiarly adapted him for that special line of work. The manner in which he has attended to even the minutest details, upon which the real value of an experiment so largely depends, and his deep interest in his work, are deserving of the highest commendation. The work of Mr. B. L. Hartwell in the chemical laboratory is deserving of equal praise in every particular. Mr. Geo. E. Adams, aside from the time employed in giving horticultural instruction and in photographic work for other divisions, has acted as my assistant in the pot and greenhouse experiments and has done all the photographic work of the division, both at the Station and elsewhere in the State, in connection with the coöperative experiments. Mr. C. L. Sargent, second assistant chemist, resigned on October 1st, to pursue the study of chemistry at the University of Michigan. To both of these gentlemen, as well as to Messrs. Tillinghast and Hartwell, my thanks are also due for their faithful discharge of the work intrusted to their care.

MISCELLANEOUS ANALYSES.

The following are miscellaneous analyses, made during the year, which have not appeared in other connections:

Analysis No. 287 was of star-fishes, the results of which are given in the report of the biological division. Nos. 288 to 291, inclusive, were samples of sodium chlorid, sodium carbonate, sodium sulfate, potassium carbonate and ammonium nitrate, which were bought for chemically pure, and which were used in connection with certain of the pot experiments, the results of which are to be published elsewhere.

292. Sample of a standard commercial plant food.

293. Sample of a special mixture sent by the State Camp Grounds Commission.

294. Formula "A" from Portsmouth Grange.

295. Formula "B" " " "

	292. Per cent.	*293.* Per cent.	*294.* Per cent.	*295.* Per cent.
Water	23.58	*	*	*
Nitrogen in nitrates	1.21	2.17	1.08	1.30
" " ammonium salts	1.59	0.07	0.00	0.00
" " organic matter	0.28	1.61	2.67	2.65
Total nitrogen	3.08	3.85	3.70	3.95
Soluble phosphoric acid	0.29	8.54	6.49	6.10
Reverted " "	2.44	*	2.19	2.70
Available " "	2.73	*	8.68	8.80
Insoluble " "	5.04	*	1.87	2.00
Total " "	7.77	9.34	10.55	10.80
Potash	4.05	8.41	9.22	8.08
Chlorin	3.68	*	5.60	5.70
Commercial valuation	*	*	$28.92	$28 59

The following is a formula for a mixture corresponding closely in chemical composition to No. 292.

* Not determined.

150	pounds	nitrate of soda.
150	"	sulfate of ammonia.
600	"	fine ground bone.
100	"	dissolved phosphate rock.
120	"	muriate of potash.
50	"	high grade sulfate of potash.
830	"	any fine material containing no manurial properties.
2000		

It is quite likely that instead of nitrate of soda, nitrate of potash was employed in the sample examined, which would, probably, increase its quality for inside uses and would give a low percentage of chlorin just as would be accomplished in the above formula by the use of nitrate of soda and high grade sulfate of potash.

296. Muriate of potash, used by the Station.

297. Calcined sulfate of potash and magnesia, used by the Station.

298. Carbonate of potash and magnesia, used by the Station.

	296. Per cent.	297. Per cent.	298. Per cent.
Water	2.09	*	*
Potash (K_2O)	50.66	21.16	33.74
Magnesia (MgO)	——	19.52	9.95

299. Nitrate of potash, used by the Station.

300. Carbonate of potash, used by the Station.

301. Carbonate of soda, used by the Station.

	299. Per cent.	300. Per cent.	301. Per cent.
Water	0.00	6.29	1.90
Potash	46.51	58.12	0.21
Soda	*	Trace.	56.72
Nitrogen	13.88	——	——
Chlorin	0.07	——	——
Silica	*	0.50	*

* Not determined.

302. Dried blood tested for Station purposes but not used in the intended experiment on account of its content of potash.

303. Dissolved bone, used by the Station.

304. Dissolved boneblack, used by the Station.

	302. Per cent.	*303.* Per cent.	*304.* Per cent.
Water	6.60	6.19	14.62
Nitrogen	12.49	3.27	——
Soluble phosphoric acid	*	3.23	12.64
Reverted " "	*	10.24	2.26
Insoluble " "	*	4.59	0.32
Total " "	0.91	18.06	15.22
Potash	0.63	——	——

305. Double superphosphate, used by the Station.

306. Dissolved phosphate rock (acid phosphate), used by the Station.

307. Slag meal[1] (basic or Thomas slag), used by the Station.

	305. Per cent.	*306.* Per cent.	*307.* Per cent.
Water	9.53	12.88	0.26
Soluble phosphoric acid	*	11.42	*
Reverted " "	*	3.50	*
Insoluble " "	0.60	1.22	*
Available " "	48.76	14.92	*
Total " "	49.36	16.14	17.87

308. Dried blood, used by the Station.

309. Nitrate of soda, used by the Station.

310. Sulfate of ammonia, used by the Station.

	308. Per cent.	*309.* Per cent.	*310.* Per cent.
Water	11.82	1.26	0.90
Nitrogen	12.24	15.62	20.72

* Not determined.

[1] The phosphoric acid in this material usually possesses a high degree of assimilability, often approaching that of superphosphates.

311. Waste lime from soda ash works.

312. Sample of New Jersey lime offered for sale in Rhode Island. This sample had been exposed to the air for a few days before testing.

313. Sample of New Jersey lime offered for sale in Rhode Island. This sample was tested as soon as received.

314. Magnesium sulfate, used by the Station.

	311.	*312.*	*313.*	*314.*
	Per cent.	Per cent.	Per cent.	Per cent.
Lime (CaO)	30.08	71.67	80.87	00.00
Magnesia (MgO)	8.73	1.96	4.17	16.06
Insoluble matter	*	0.93	*	——

315. Floats (finely ground undissolved phosphate rock), used by the Station.

316. Pure raw knuckle bone flour, used by the Station.

317. Fine ground steamed bone, used by the Station.

318. Tankage (animal dust), used by the Station.

	315.	*316.*	*317.*	*318.*
	Per cent.	Per cent.	Per cent.	Per cent.
Water	0.73	*	6.48	9.24
Nitrogen	——	3.83	2 49	5.27
Phosphoric acid	29.04	26.12	24.93	15.29

319. Water, from spring near Station quarry.

320. Water, from village well, Kingston.

	319.	*320.*
	Parts per million.	
Free ammonia	.02	.05
Albuminoid	.05	
Chlorin	15.00	28.00

* Not determined.

OBSERVATIONS IN CONNECTION WITH A SOIL TEST CONTINUED FOR EIGHT SUCCESSIVE YEARS.

H. J. WHEELER AND JOS. A. TILLINGHAST.

This experiment was begun in 1890. Each year nitrogen has been applied in form of nitrate of soda; phosphorus, in form of dissolved boneblack; and potassium, in form of muriate of potash. The quantities of these materials applied per acre in 1890 were as follows:

150 pounds nitrate of soda.
350 " dissolved boneblack.
150 " muriate of potash.

In 1891 no material change was made. In 1892, however, the quantities were increased, and the annual applications have remained till the present time as follows:

480 pounds nitrate of soda.
600 " dissolved boneblack.
200 " muriate of potash.

In 1893 the southern third of plot 7 was treated with air-slacked lime at the rate of 2½ tons per acre. In 1894 this portion received a further application of air-slacked lime at the rate of half a ton per acre, and the balance of the southern half of the plot, which was not limed in 1893, received 3 tons per acre, or, in other words, sufficient to make a uniform application of 3 tons per acre over the entire southern half of the plot.

In the years 1890 to 1893, inclusive, plot 7 received but one-third as much nitrate of soda as the other plots to which it was

applied. Since that time a full application of nitrate of soda has been made upon that plot annually. Maize was the only plant employed in this experiment from 1890 to 1893 inclusive. The first year it indicated a greater deficiency of potash than of phosphoric acid, but in the three subsequent years a most striking deficiency of phosphoric acid was indicated. The details of these results may be found in the Experiment Station Reports for the respective years, under the title "Coöperative Field Experiments with Indian Corn."

The observations of three consecutive years having shown so conclusively that phosphoric acid was the most needed ingredient, the question suggested itself, in consideration of the varying feeding power of different plants, as shown by Wagner and others, that possibly other plants might, upon the same soil, stand more in need of some other manures than of phosphates. In order to secure, if possible, a clue as to the probability of such a thing, two rows each of thirty-seven varieties of plants were grown across the plots in 1894. The observations, both with single substances and combinations of two, indicated that the white bean, sunflower and summer squash might be more benefited by applications of potash than of phosphoric acid. In no case was nitrogen shown to have been the most deficient element. Certain of the plants which showed phosphoric acid to be chiefly deficient indicated that the second need was nitrogen, and others that the lack of potash stood second. Since but two rows of any one kind of plants were grown in 1894, these results were looked upon not as conclusive, but as merely indicative.

In 1895, ten kinds of plants were employed, among which were white beans, sunflower, and two varieties of the summer squash. The results of the experiment in 1895 were far from satisfactory, for reasons fully discussed in the report on the soil test in the Station Report for that year, and could, like those in 1894, be considered as no more than indicative. They were, however, much more conclusive in some particulars than the results of the previous year. The data secured with beans were not at all conclusive, and those ob-

tained with the sunflower and summer squashes indicated the opposite of those of 1894, or that phosphoric acid was more deficient than potash. In 1896 the number of plants employed was reduced to six, in order that a greater number of rows of each might be grown. The entire area of all the plots was also treated with air-slacked lime at the rate of 2½ tons per acre before the crops were planted. This was done to ascertain if the same results would be obtained from a soil deficient in carbonate of lime, before and after that substance was applied. Maize was introduced as a check, on account of the fact that it had for so many years indicated a deficiency of phosphoric acid. Sunflowers and beans were grown in 1896, summer squashes being omitted. The other plants employed were spring rye, golden millet and crimson clover. The data secured with the sunflower pointed again to phosphoric acid as most deficient, followed closely by potash, and more closely, in fact, than was the case with maize, rye and millet, which, in previous years, pointed strongly to phosphoric acid as being much more deficient than potash. The results, taken as a whole, indicate that the sunflower requires much more potash than many other plants, or has less ability to extract what it needs from the soil. One or the other or both of these points seem to have an important bearing upon the results with this particular plant. Beans indicated, as a whole, a rather greater need of potash than of phosphoric acid.

In 1897, no further application of lime was made. The plants employed were crimson clover, common white bean, sunflower, summer squash and maize. Maize was employed for the same reason as in 1896, namely, because it was known, from many extended trials, to indicate that the particular soil under experiment was deficient in phosphoric acid, and it was therefore admirably adapted to serve as a check on the season's results. Had this precaution not been taken one might have been led to entirely false conclusions in relation to the other crops, as will be seen from a study of the weights given in the following table:

Table Showing the Weights, in Pounds, of the Different Crops at the time of Harvesting.

Names of Crops.	Plot 1.		Plot 2.		Plot 3.		Plot 4.		Plot 5.		Plot 6.		Plot 7.	
	Nitrate of soda, 24 lbs.		Dissolved bone-black, 30 lbs.		Muriate of potash, 10 lbs.		Nitrate of soda, 24 lbs. Dissolved bone-black, 30 lbs.		Nitrate of soda, 24 lbs. Muriate of potash, 10 lbs.		Dissolved bone-black, 30 lbs. Muriate of potash, 10 lbs.		Dissolved bone-black, 30 lbs. Muriate of potash, 10 lbs. Nitrate of soda, 24 lbs.	
	North and South rows.	Average of all rows.	North and South rows.	Average of all rows.	North and South rows.	Average of all rows.	North and South rows.	Average of all rows.	North and South rows.	Average of all rows.	North and South rows.	Average of all rows.	North and South rows.	Average of all rows.
Crimson clover — North rows.	15.8		20.3		20.3		46.0		30.0		52.5		66.3	
Crimson clover (undried).		20.2		17.4		32.6		52.8		37.7		48.5		64.1
Crimson clover — South rows.	24.5		14.5		44.8		59 5		45.3		44.5		61.8	
Com. white bean — North rows.	7.0		1.5		9.5		10.0		14.0		14.3		20.0	
Com. white bean (total crop)		8.9		2 0		9.8		11.2		17 0		15.7		19 8
Com. white bean — South rows.	10.8		2.5		10.0		12.8		20.0		17.0		19.5	
Com. white bean — North rows.	3.8		0 6		5.3		6.3		8 2		9.0		12.3	
Com. white bean (beans)		5.3		1.0		5 3		6.7		9.6		10.1		11.8
Com. white bean — South rows.	6.7		1 4		5.3		7.0		11.0		11.1		11.3	
Sunflower — North rows.	38 0		7.5		72.0		28 5		70.0		67.5		54.0	
Sunflower (undried)		32.4		18.3		72.3		32.4		72 0		84.8		96.0
Sunflower — South rows.	26.8		29.0		72.5		36.3		74.0		102.0		138.0	
Summer squash — North rows.	0.3		0.1		3 8		12.3		15.5		35.5		44 3	
Summer squash (ripe)		0.9		0.3		10.2		20.3		25.7		37 2		49.3
Summer squash — South rows.	1.5		0.5		16.5		28.3		35.8		38.8		54.3	
Maize fodder — North rows.	59.0		20.8		62.0		84.3		84.0		113.0		136.0	
Maize fodder (undried)		51.7		16.3		66.9		90.2		111.3		115.4		141.9
Maize fodder — South rows.	44.3		11.8		71.8		96.0		138.5		117.8		147.8	

In comparing the weights in the above table it should be stated that those from the south rows are considered more reliable than those from the north ones, by virtue of the fact that the field seemed originally less uniform in fertility at the north end.[1] This may have been caused partly, perhaps, by a slight depression on that end of the plots, and partly by some previous treatment of the soil.

Comparing the weights of crimson clover it will be seen that they are alike in the case of the north rows, where potash and phosphoric acid were each applied singly (plots 2 and 3), while the weight on the nitrogen plot (1) was less. The south rows, in connection with the same plots, show that potash was most deficient, followed in turn by nitrogen and phosphoric acid.

In the case of the combinations of two manurial substances the results are very inconclusive.

In comparing the results with the common white bean the weights, where the manurial substances were applied singly, point, in the case of both the north and the south rows, to a greater deficiency of potash than of phosphoric acid. This is further indicated, by both sets of rows, from the fact that nitrogen and potash gave a greater yield than nitrogen and phosphoric acid. The weights of beans, separated from the vines (straw), agree in this particular with the results obtained with the entire plant.

The same may be said of the sunflower as of the common white bean, for, whether used singly or in conjunction with other substances, potash gave better results than phosphoric acid.

The summer squash gave results also concordant, in this respect, with the common white bean and sunflower. If one were to have based a judgment of these results upon the data obtained with the crops just mentioned, the conclusion would have seemed, probably justifiable, that they needed potash more than phosphoric acid, or, in other words, that potash was the more deficient ingredient. In view of the fact that, in a number of seasons, maize has shown a most striking deficiency of phosphoric acid as com-

[1] See Figs. A and B in the 6th An. Rpt. of this Station for the year 1893.

pared with that of potash, it becomes particularly interesting to note the results with it as shown in the preceding table. On the plot where phosphoric acid only, was applied, the weights of maize fodder from the north and south rows were 20.8 and 11.8 pounds respectively, and upon the plot receiving muriate of potash only the corresponding weights were 62 and 71.8 pounds. Again, upon the plot receiving nitrogen and phosphoric acid they were respectively, 84.3 and 96 pounds, and upon that receiving nitrogen and potash 84. and 138.5 pounds. Practically, then, there was, in one case, no difference in the results, in contrast to the great difference in previous years in favor of phosphoric acid, and in the three other cases potash gave better returns than phosphoric acid, indicating that the latter substance had for some reason lost its former efficacy. It is obviously of the greatest interest to ascertain to what these apparently remarkable results may be attributed. The only conditions which were noticeably different from those of former years, when maize had showed a striking deficiency of phosphoric acid, were those produced by the frequent and heavy rainfalls throughout most of the season of growth, and those possibly brought about by the lime applied the previous season. In regard to the rainfall it was so heavy during the earlier part of the season as to seriously interfere with the growth of most cultivated plants.

If the changes were attributable solely to the lime, it would have seemed probable that similar results would have been obtained in 1896, which was not the case, yet it must be borne in mind that the lime which was applied in the spring of 1896 had, a year later, become much more thoroughly incorporated with the soil as the result of the subsequent tillage.

If one were to take into account nothing but the poor growth upon the phosphoric acid plots, he might with some reason infer that, owing to the excessive moisture, the soluble phosphoric acid of the superphosphate was disseminated in the soil with unusual rapidity, and, coming in contact, as it presumably did, with iron and aluminum oxids, entered into comparatively insoluble

combinations with them, which the plants were unable to utilize. It might also be reasonably claimed that, owing to the previous liming, there was a sufficient quantity of lime present to cause the rapid change of some of the phosphoric acid to tricalcic phosphate, which would have lessened its otherwise high degree of assimilability.

Such an explanation as this does not seem to account for the facts, for the reason that where all three of the so-called essential elements were applied, the yield of maize was much greater than where only potash and nitrogen were applied, which would indicate that a considerable amount of readily assimilable phosphoric acid must have stood at the disposal of the plant. Furthermore, the very unusual growth upon the plot which had received nothing but potash for a long period of years, and also that upon the plot which had received nitrogen and potash, does not admit of such an explanation.

The results cannot be explained upon the ground that the lime had facilitated the nitrification of the humous nitrogen in a greater degree upon certain plots than upon others, whereby the supplies of assimilable nitrogen were rendered unequal. The abundant annual applications of nitrate nitrogen to certain of the plots preclude such an explantation.

The most plausible idea which has thus far suggested itself is that the lime, or more probably the lime aided by the unusual quantity of moisture, had rendered more assimilable than formerly certain inert forms of phosphoric acid already in the soil.

In how far benefit from liming this soil may be attributable to its having increased the assimilability of inert phosphates remains to be ascertained.

SUMMARY.

The first year's experiment with maize indicated a probable need of potash. Experiments for three successive years with the same crop showed in a most decisive manner that phosphoric acid was more deficient in the soil than nitrogen or potash.

Most of our agricultural plants gave indications that their in-

dividual requirements for phosphoric acid on our soil were determinable in a soil test as well by maize, as by the use of each of them.

Sunflowers, by virtue of greater requirements for potash or of less ability to extract it from the soil, are probably not well calculated for use in determining phosphoric acid deficiencies for most other plants. White beans, summer squashes and crimson clover seem also less desirable for such a use than the cereals.

Liming, an unusual amount of water, or possibly both factors seem capable of rendering assimilable some of the otherwise inert phosphates already existing in the soil.[1]

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[1] Compare Dehérain, Traité de Chemie Agricole, Paris, 1892, pp. 524, 525.

A STUDY OF THE NEEDS OF CERTAIN RHODE ISLAND SOILS.

H. J. WHEELER, C. O. FLAGG AND G. E. ADAMS.

In 1890 experiments were begun at eleven different points in the State for the purpose of ascertaining, if possible, what element or elements of the three so-called essential ones[1] were chiefly deficient. In most cases all three of the ingredients were lacking, though in different degrees, in the various soils. Such old pasture and mowing lands as were apparently in poor condition were found, in most cases, to need particularly phosphatic manures. In the course of these experiments, which also involved comparative trials of nitrogen, as sulfate of ammonia, dried blood, and nitrate of soda, the first mentioned form of nitrogen gave bad results in certain cases. In two instances this was not true until the second or third season that it was used. Subsequent experiments showed, conclusively, that the failure of the sulfate of ammonia was due to a lack of carbonate of lime or other basic ingredients in the soils. Having learned, in this way, that the soil of the Station farm as well as that on the farm of H. E. Lewis, at Hope Valley, and probably that on a field at Abbott's Run, were lacking in carbonate of lime, an experiment was conducted on the farm of F. P. Babcock, at Westerly, which showed a similar soil deficiency. In the latter case two plots were manured alike with superphosphate, muriate of potash and nitrate of soda, one being limed and the other unlimed. On the unlimed plot but 63 pounds

[1] Potassium, phosphorus and nitrogen.

of mangel wurzel were obtained, and from the limed one 155.5 pounds.

In 1896 experiments[1] similar to that at Westerly were conducted at Niantic, Hope Valley, Hamilton, Slocumville, Jamestown, South Portsmouth, Warren, Harrisville, Foster Center, Summit and Kingston, in all but one of which air-slacked lime decidedly increased the growth of table beets. The smallest gain was 21 per cent., while, at Slocumville, the crop was increased about 100 times by liming. In trials of barley upon the same plots the benefit from liming was noticeable in a less number of instances and in a less striking degree than with beets.

Clover was sown with the barley, in 1896, and in September of the same year, after the removal of the table beets, the space which they had occupied was seeded with redtop and Timothy, so that results could be obtained, in 1897, with clover and also with the mixed grasses.

EXPERIMENTS WITH CLOVER AND MIXED GRASSES FOR DETERMINING THE NEED OF LIME IN SOILS.

Experiments have been continued, in 1897, upon eight of the eleven soils upon which experiments with barley and beets were started in 1896. Two plots, each 27x27 feet and separated by a path six feet wide, were employed in each experiment. The area of an individual plot was about one-sixtieth of an acre. One of the plots in each experiment was limed, in the spring of 1896, with air-slacked lime, at the rate of 82 pounds per plot, or 2½ tons per acre. In 1897 one-half of each plot was in clover and the other in grass.

	Year of 1896.	Year of 1897. Pounds.	
Manures applied.	Pounds.	On clover section.	On grass section.
Muriate of potash........ ...	5	2.5	2.5
Nitrate of soda..	5	1.0	2.5
Dissolved boneblack.......	15	7.5	7.5

[1] Ninth An. Rpt. R. I. Ag'l Expt. Station (1896), pp. 282-298.

From the foregoing it will be seen that the plots were manured at the same rate in 1897 as in 1896, excepting the clover sections which received but two-fifths as much nitrogen as the rest of the plot. The amount of nitrogen was reduced on the clover sections in consideration of the fact that clover is capable, after a certain stage and under favorable soil conditions, of drawing its supply of nitrogen chiefly from the air within the soil. The manures were applied in the spring of 1897, after the growth of the grass and clover had begun. In all cases the red clover seed (2¾ oz. per section) was sown with the barley in the spring of 1896. The grass seed employed per section consisted of 2¼ ozs. of redtop (*Agrostis vulgaris*) and 3 ozs. of Timothy (*Phleum pratense*). Germination tests were made with both lots of seed. In the case of the red top the experiment was begun Sept. 22d, the first sprouts appeared on Sept. 25th, and the last on Oct. 1st; half of the lot sprouted in five days, and 56 of the 100 seeds sprouted. The experiment with Timothy seed was begun Sept. 22d, the first sprouts appeared Sept. 25th, the last Sept. 28th; half of the lot sprouted in three days, and 97 of the 100 seeds sprouted. The range in temperature was 1°C. in both cases.

In comparing the results which follow, it will be seen that in many instances red top predominated upon the grass sections, a fact which could not, in the light of the above test, have been attributed to probable faulty germination of the Timothy seed.

Owing to the bearing of the field notes upon the experiments, the data for each will be presented individually rather than grouped in tabular form.

Experiment on the farm of Geo. H. Larned, Hamilton, R. I.

Unlimed clover section, first crop.—The total weight of undried clover and grass was 66.9 pounds, of which 3.8 pounds consisted of red clover. The grass was chiefly redtop. (*Fig. 2.*)

Second crop.—The second crop consisted of clover only, and weighed less than 0.1 of a pound. (*Fig. 3.*)

Limed clover section, first crop.—The total weight of undried clover and grass was 204.6 pounds. It seemed to consist of about equal parts of clover and redtop, mixed with traces of other grasses. (*Fig. 2.*)

Second crop.—The second crop consisted of a mixture of about equal parts of grass and clover, and weighed, undried, 74.4 pounds. (*Fig. 3.*)

Unlimed grass section, first crop.—The total weight of undried grass was 151.6 pounds. It consisted apparently of about equal parts of redtop and Timothy, with some "charlock." No second crop was obtained. (*Fig. 1.*)

Limed grass section, first crop.—The total weight of undried grass was 205.1 pounds, consisting chiefly of Timothy, mixed with some redtop. There was no second crop. (*Fig. 1.*)

	Unlimed section. Pounds.	Limed section. Pounds.
Total crop of clover	67.0	279.0
" " " grass	151.6	205.1

Experiment on farm of B. H. Nixon, Summit, R. I.

Unlimed clover section, first crop.—The total weight of undried material cut upon this section was 77.9 pounds. About one-third of the whole consisted of common sorrel and other weeds. The stand of clover was poor.

Second crop.—The second crop of clover on this section weighed, undried, 11.3 pounds. (*Fig. 9.*)

Limed clover section, first crop.—The weight of undried material from this section was 127.6 pounds. The amount of weeds present, including common sorrel, was small. The stand of clover was good.

Second crop.—The second crop of clover weighed, undried, 63.3 pounds. (*Fig. 9.*)

Unlimed grass section, first crop.—The undried grass from this section weighed 49.3 pounds, the mixture apparently containing more redtop than Timothy. There was no second crop.

Limed grass section, first crop.—The weight of undried grass from this section was 91.9 pounds. The grass was chiefly Timothy, mixed with a little redtop. There was no second crop worth cutting.

	Unlimed section. Pounds.	Limed section. Pounds.
Totol crop of clover....................	89.2	190 9
" " " grass.....................	49.3	91.9

Experiment on farm of John B. Spears, Foster Centre, R. I.

Unlimed clover section, first crop.—The weight of undried material was 140.2 pounds. The stand of clover was very irregular and the growth fair. Some sorrel was also present. (*Fig. 5.*)

Second crop.—The second crop, which consisted of practically nothing but clover, weighed, undried, 16.0 pounds. (*Fig. 6.*)

Limed clover section, first crop.—The weight of undried material was 195.6 pounds. There was a good and full stand of clover, with but little sorrel. (*Fig. 5.*)

Second crop.—The weight of undried clover obtained at the second cutting was 36.9 pounds. (*Fig. 6.*)

Unlimed grass section, first crop.—The weight of undried material was 104.9 pounds. About one-tenth of the grass seemed to be Timothy and the balance redtop. Some Roman wormwood (*Ambrosia artemisiaefolia L.*) was present with the grass. (*Fig. 4.*)

A second crop was not obtained.

Limed grass section, first crop.—The undried material weighed 124.1 pounds. The grass was mostly Timothy, the balance being redtop. About the same amount of Roman wormwood was present as on the unlimed section. There was not enough second growth to pay for cutting. (*Fig. 4.*)

	Unlimed section. Pounds.	Limed section. Pounds.
Total crop of clover.....................	156.2	232.5
" " " grass.....................	104.9	124.1

Experiments on farm of W. E. Fitz, Harrisville, R. I.

Unlimed clover section.—The weight of undried clover was 97.5 pounds. The clover, when cut, was still quite green and succulent, while that on the limed section was quite dry and had lost some of its leaves. This may have been due to the influence of the lime in hastening the maturity of the crop, or to the fact that the unlimed plot lay slightly lower than the other and was naturally more moist. Both factors may have influenced the results. In all other locations in the State where experiments were conducted, the clover was still in good condition, showing that the soil or atmospheric conditions must have been here especially conducive to early maturity. No second crop was cut. (*Fig. 8.*)

Limed clover section.—The clover, which was already dry and had lost some of its leaves, weighed, without further drying, 63 pounds. No second crop was cut. (*Fig. 8.*)

Unlimed grass section.—The weight of undried grass was 43 pounds. It consisted almost entirely of Timothy, mixed with very little redtop, and was already quite dry when cut. There was no second crop. (*Fig. 7.*)

Limed grass section.—The weight of undried grass was 44.2 pounds. As on the unlimed plot, the grass was quite dry when cut, it also consisted almost entirely of Timothy, mixed with a little redtop. There was no second crop. (*Fig. 7.*)

A most striking feature of this experiment was that the grass upon the unlimed plot should have consisted chiefly of Timothy, while in the other experiments it was mostly redtop. It will have been noticed, in the experiments described previously, that liming increased in a wonderful degree the relative amount of Timothy, as compared with redtop. Many observations made at this Station show that Timothy is much more seriously affected by a deficiency of basic ingredients in soils, than redtop, and the success of the Timothy upon this soil, finds its ready explanation in the fact that the soil when tested with blue litmus paper, in 1896,

was found to be approximately neutral, or, at least, but slightly acid.

	Unlimed section Pounds.	Limed section. Pounds.
Total crop of clover	97.5*	63.0†
" " grass	43.0	44.2

Experiment on farm of N. Horace Peckham, So. Portsmouth, R. I.

Unlimed clover section, first crop.—The weight of undried material obtained was 134.1 pounds. The clover was scattering, and was mixed with many weeds. (*Fig. 14.*)

Second crop.—Owing to accidental injury to one corner of one of the clover plots subsequent to cutting the first crop, it became necessary in harvesting the rowen to cut only a portion of each plot, representing equal areas. On this account the weights do not show the total yield of crop upon the sections, but for comparative purposes they are practically as good, since care was exercised to select areas as truly representative as possible of the entire section. The weight of undried clover upon the area thus harvested was 36.3 pounds.

Limed clover section, first crop.—The weight of undried material was 196.8 pounds. The stand of clover was very good, and it was mixed with but few weeds. (*Fig. 14.*)

Second crop.—The second crop of clover from the selected area weighed, undried, 48.8 pounds.

Unlimed grass section.—The weight of undried grass amounted to 126.7 pounds. It consisted of Timothy, mixed with a little redtop. There was no second crop. (*Fig. 13.*)

Limed grass section.—The weight of undried grass amounted to 148.5 pounds. The grass upon this section consisted of practically pure Timothy. No rowen was cut upon this section, yet the growth was much better than upon that which was unlimed. (*Fig. 13.*)

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* Very green and succulent when cut.

† Very dry when cut.

	Unlimed section. Pounds.	Limed section. Pounds.
Total crop of clover..	170.4	245.6
" " " grass	126.7	148.5

Experiment on farm of E. N. Tefft, Jamestown, R. I.

A neighboring flock of geese, or other farm animals gained access to these plots at an advanced period in the growth of the clover and injured it to such an extent that no effort was made to record its weight. The grass sections were apparently uninjured. The grass upon both sections appeared to consist almost entirely of Timothy, and was very dry when cut. (*Fig. 12.*)

	Unlimed section. Pounds.	Limed section. Pounds.
Total crop of grass	33.7	43.8

Experiment on farm of Alfred Eldred, Slocumville, R. I.

Unlimed clover section.—The growth upon this section consisted chiefly of weeds. They were separated from the clover and found to weigh 72.6 pounds. The undried clover weighed but 7.3 pounds. A second cutting was not made. (*Fig. 11.*)

Limed clover section.—All of the prominent weeds were pulled out before attempting to cut the clover, but owing to the impracticability, at the time, of removing all of the small ones, some remained and were cut and weighed with the clover. The weight of undried material thus obtained was 95.4 pounds. (*Fig. 11.*)

Unlimed grass section.—Owing to the fact that this section was not seeded to grass until the spring of 1897, the grass was not so far advanced when the crop was cut as was the case in the other experiments.

On account of the lodging of the grass it became necessary to cut it, in order to secure fairly comparable results, at about the time that on the other experiments was harvested, even though it was not yet sufficiently mature. The growth consisted chiefly of redtop

which was just beginning to head out. Small quantities of Timothy and sorrel, only, were present. The total weight of the very succulent, undried material was 122.9 pounds. No rowen was harvested. (*Fig. 10.*)

Limed grass section.—This was seeded at the same time as the unlimed section just described, and, in order to secure as good comparative results as possible, its cutting was necessitated at the same time as that of the grass on the other section. The growth consisted chiefly of Timothy, mixed, however, with a little redtop and a few miscellaneous weeds. The Timothy, though not in full bloom, was much nearer maturity than the redtop on the other section, and probably for that reason contained a considerably less percentage of water, which correspondingly lessened its weight. The total weight of undried material was 117.3 pounds. No rowen was harvested. (*Fig. 10.*)

	Unlimed section. Pounds.	Limed section. Pounds.
Total crop of clover	7.3	95.4
" " " grass	122.9	117.3

Experiment on farm of the Experiment Station, Kingston, R. I.

Unlimed clover section, first crop.—In this experiment the clover was separated from the sorrel and other weeds with great care, an operation which required the work of several men for a number of hours. The total weight of undried clover (from weights of small lots, taken at frequent intervals, as the cutting progressed) was 68.8 pounds. The weeds consisted chiefly of sorrel, and weighed, undried, 53.3 pounds. (*Fig. 17.*)

Second crop.—The second crop of clover was free from weeds, and, undried, weighed 73.5 pounds. (*Fig. 16.*)

Limed clover plot, first crop.—Here, as well as on the unlimed section, the clover and weeds were separated, and the weight of each recorded. The undried clover was found to weigh 201.6 pounds, and the sorrel, 1.5 pounds. (*Fig. 17.*)

Second crop.—The second crop of clover on this section was also free from weeds and weighed, undried, 103.5 pounds. (*Fig. 16.*)

Unlimed grass section, first crop.—The grass upon this plot consisted chiefly of redtop, mixed with traces of Timothy and some weeds, consisting principally of sorrel. The weeds, as in the case of the clover, were separated from the grass. (*Fig. 15.*)

The weights of undried material were as follows: grass, 128.0 pounds, and weeds (mostly sorrel), 11.3 pounds.

Second crop.—The second crop consisted chiefly of redtop, and weighed 10.0 pounds, after drying sufficiently to store in the barn.

Limed grass section, first crop.—The grass upon this section was free from weeds, and consisted of Timothy, with but traces of redtop. Its weight, undried, was 175.5. (*Fig. 15.*)

Second crop.—The second crop consisted, like the first, almost wholly of Timothy and weighed 12.5 pounds, after drying sufficiently to store in the barn.

This experiment, and the one at Slocumville, were two of the most striking examples conceivable, of the effect of lime upon acid soils in promoting particularly the growth of Timothy. Even though the same kind of seed was sown upon both sections, the crop upon the unlimed ones was almost exclusively redtop, and that upon the limed ones, Timothy.

From several other experiments conducted upon the Experiment Station farm, it appears probable that this is not explainable upon the ground that the lime had directly injured the redtop, but rather that it had rendered the soil conditions so favorable to the Timothy, that it was able to get the better of the redtop in the natural struggle for existence. A closely analogous case is that of common sorrel and clover. The more acid the soil becomes, within reasonable limitations, the better sorrel seems to thrive. It will make a good growth on limed soil, and it is said to have been seen growing even on an old mortar bed. Liming does not therefore destroy sorrel, but, on the contrary, it puts the soil in a condition so favorable to the growth of clover that the

latter, owing to its larger size, overcomes the former, and thus takes possession of the land.

EXPERIMENTS WITH BEETS, BEGUN IN 1897.

Experiment on the farm of John F. James, Moosup Valley, R. I.

This experiment was conducted upon an old pasture which was practically exhausted, and in many places badly infested with moss. Tests with blue litmus paper showed that the soil was decidedly acid, and considerable humus directly soluble in ammonia was also present, both tests indicating need of lime. The soil was a gravelly loam, and was plowed in the spring of 1897. After a preliminary harrowing, two plots, each 12 x 30 feet, were laid out, separated from each other by a path about six feet wide. Each plot contained about one-twentieth of an acre, and received the following manures:

	Pounds per plot.	Pounds per acre.
Nitrate of soda	2.5	300
Muriate of potash	2.5	300
Dissolved boneblack	7.5	800

In addition, one plot received air-slacked lime at the rate of 41 pounds per plot, or 4,920 pounds per acre. The lime and manure mentioned above were broadcasted and thoroughly worked into the soil.

A like weight of mangel-wurzel seed was planted upon each plot, and, when the plants were sufficiently large, the plots were thinned uniformly. It was noted that there was no particular difference in the germination of the seed upon the two plots, but soon after germination many of the plants on the unlimed plot died without making further growth, while others turned red and lingered longer, though making but a feeble growth. Some plants on the unlimed plot made a fair growth and produced beets of considerable size. The differences, which were noticeable early in

the experiment, became more marked as the season advanced. A few weeks before the time for harvesting the beets, a cow, in spite of a good fence, gained access to the plots and destroyed some of the beets upon one-half of the limed plot. On this account the crop on but half of each plot was weighed.

	Pounds $\frac{1}{240}$ acre.		Pounds per acre.	
	Limed.	Unlimed.	Limed.	Unlimed.
Mangel-wurzels	174.0	25.3	41,760.0	6,072.0

From the foregoing it will be seen that there was a gain from liming of 35,688 pounds, or nearly 18 tons per acre. (*Fig. 19.*)

Experiment on the farm of Benj. Barton, East Greenwich, R. I.

Five plots were employed in this experiment, each 12x20 feet and separated by paths 4 feet wide. The acid character of the soil was indicated by its action upon blue litmus paper. After plowing and harrowing somewhat, the lime and fertilizer were applied broadcast and thoroughly worked into the soil. Red table beets were sown, care being taken to employ like weights of seed upon each plot. The beets in this experiment were not thinned sufficiently, and the plots were so badly infested with "dog" grass that it was, practically, impossible to keep the soil free from it. These factors interfered with the growth of the beets, but since the conditions were, practically, the same on all of the plots, these circumstances did not interfere with the results so far as concerned what particular treatment of the soil was *best.* The relative differences would, however, probably have been more striking had all of the conditions been ideal. The plot which was limed received 41 pounds, the same rate per acre as in the Moosup Valley experiment. The manurial substances applied to each plot and the weights of the beets obtained are given in the subjoined table. It will be seen that this experiment was designed to test the needs of the soil in relation to potash, phosphoric acid and nitrogen, as well as lime.

No. of Plot.	MATERIALS APPLIED.	Pounds of Beets.
1	2.5 pounds, muriate of potash; 2.5 " nitrate of soda	3.8
2	2.5 " muriate of potash; 7.5 " dissolved boneblack	8.9
3	2.5 " nitrate of soda; 7.5 " dissolved boneblack	21.5
4	2.5 " nitrate of soda; 2.5 " muriate of potash; 7.5 " dissolved boneblack	35.4
5	Same as plot 4, with the addition of 41 pounds of air-slacked lime	55.3

From the foregoing table it will be seen that the yield upon plot 2, which received potash and phosphoric acid, was greater than that upon plot 1 where potash and nitrogen were used. This would indicate that phosphoric acid was needed more than nitrogen. Again, the yield upon plot 3, which received nitrogen and phosphoric acid, being greater than that on either plot 1 or plot 2, indicates that nitrogen was needed more than potash. Furthermore, the yield upon plot 4, which received all three elements, being much greater than that upon plot 3, indicates that potash was deficient, but that it was incapable of exercising its maximum effect until used in connection with considerable nitrogen and even more phosphoric acid. Such tests as these are more conclusive if continued for several years, but may throw valuable light upon the needs of the soil in a single year.

By a comparison of the result on plot 4 with that on plot 5, which was treated the same except for the liming, it will be seen that by the addition of lime there was a gain of 19.9 pounds, or 56.1 per cent., by liming.

Comparing this result with that at Moosup Valley, it is at once

seen that the need of lime in this East Greenwich soil is much less than there, and probably from 1,000 pounds to a ton per acre would have been ample, while even two tons per acre or more may have been a more profitable quantity to use on the Moosup Valley soil.

Experiment on the farm of S. D. Stone, Apponaug, R. I.

This experiment was laid out exactly like that on the farm of Mr. Barton, at East Greenwich, the lime, chemicals and seed of the red table beets having been applied at the same rate and taken from the same lot. This soil was extremely light and sandy, and there was such a lack of lime that nearly all the young beet plants died except upon the limed plot. Even here, owing to the extreme lightness of the soil and probably also to the loss of nitrate of soda by leaching induced by the many heavy rains, the growth was extremely poor. On the unlimed plot the beets weighed but 0.3 of a pound, and on the limed one, 12.4 pounds. In view of the extreme lightness of the soil it is probable that a ton of lime per acre would have been a more desirable application than that used, which was nearly 2½ tons. (*Fig. 18.*)

It was designed to compare the results of a soil test in the field with those of one made in pots, and, in order to assist in accomplishing this purpose, Mr. Stone kindly sent to the Sation a barrel of surface soil from the location of the field experiment. As already explained, the field test was a failure except so far a concerned its showing the requirement of the soil for lime. The pot experiments were conducted in zinc pots exactly like those employed by Prof. Paul Wagner, of Darmstadt, Germany. A sample pot was kindly loaned by Dr. J. B. Lindsey, of Amherst, Mass., who secured and brought one with him from Darmstadt. The pots are 10 inches in diameter and of like depth, without an opening at the bottom. A tube passes down the outside of the pot and enters it on one side near the bottom. The water is introduced through this tube and then passes under a curved piece

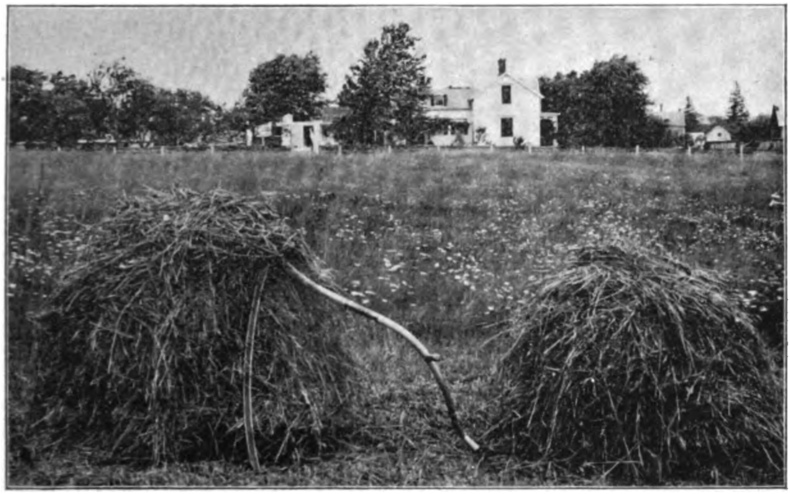


Fig. 1.—Grass (first crop). Hamilton, R. I.

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 2.—Clover and Grass from Clover Plots (first crop). Hamilton, R. I.

Clover and Grass. **Grass.** **Clover.**

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG. 3.—CLOVER (second crop). Hamilton, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG 4.—GRASS (first crop). Foster Center, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG. 5.—CLOVER (first crop). Foster Center, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG. 6.—CLOVER (second crop.) Foster Center, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG. 7.—GRASS (first crop). Harrisville, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

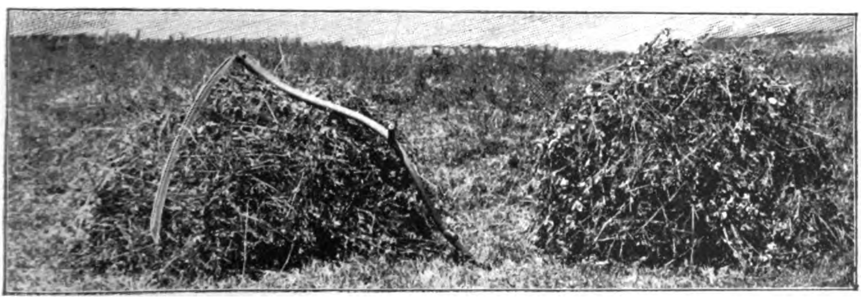


FIG. 8.—CLOVER (first crop). Harrisville, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 9.—Clover (second crop). Summit, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

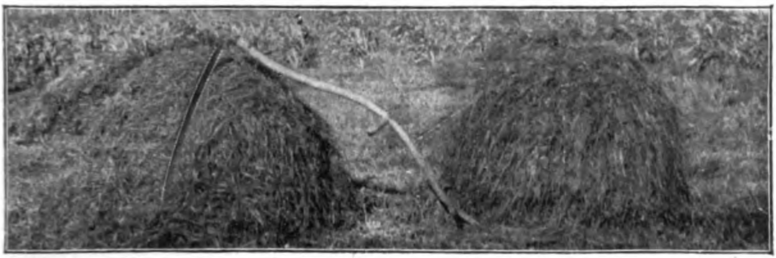


Fig. 10.—Grass (first crop). Slocumville, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 11.—Clover (first crop) Slocumville. R. I.
Clover. Clover. Weeds.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 12.—Grass (first crop). Jamestown, R. I.
Limed. ***Unlimed.***
Both plots manured alike with potash, phosphoric acid and nitrogen.

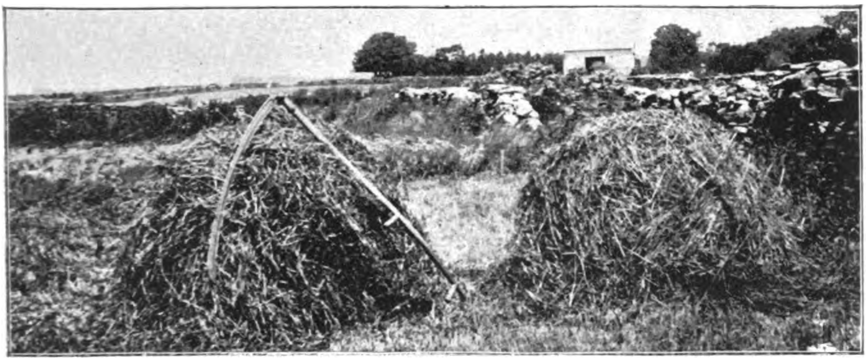


Fig. 13.—Grass (first crop). So. Portsmouth, R. I.
Limed. ***Unlimed.***
Both plots manured alike with potash, phosphoric acid and nitrogen.

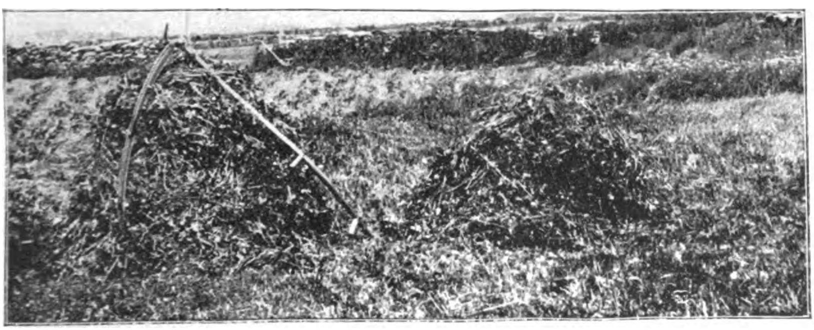


Fig. 14.—Clover (first crop). So. Portsmouth, R. I.
Limed. ***Unlimed.***
Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 15.—Grass (first crop). Kingston, R. I.

Grass. Grass. Weeds.

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 16.—Clover (second crop). Kingston, R. I.

Limed. *Unlimed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

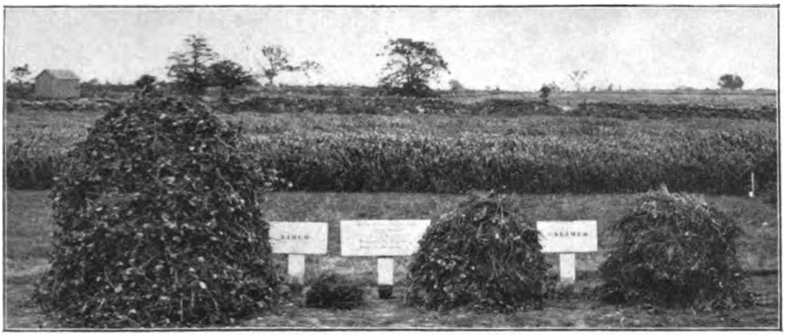


FIG. 17.—CLOVER (first crop). Kingston, R. I.
Clover. Clover. Weeds.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

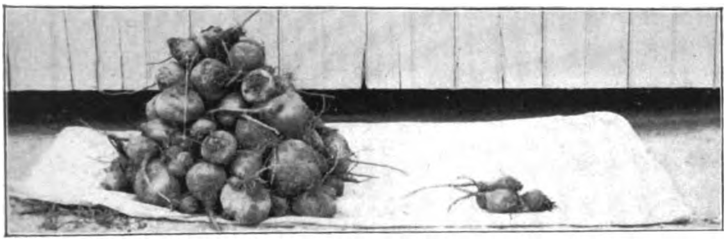


FIG. 18.—TABLE BEETS. Apponaug, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

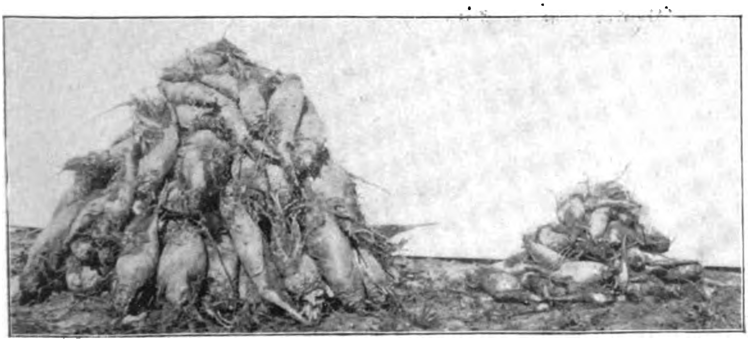


FIG. 19.—MANGEL-WURZELS. Moosup Valley, R. I.
Limed. *Unlimed.*
Both plots manured alike with potash, phosphoric acid and nitrogen.

of zinc which lies upon the bottom and reaches across the pot. This permits, by means of its notched edges, a ready circulation of water to the entire area of the bottom of the pot. The water capacity of the soil was determined, and, by daily weighings, the amount of water suitable to the best growth was added. The pots were placed on a truck and were kept out of doors during pleasant weather and run under a glass house at night and during rain storms. The other data, bearing upon this experiment, are given in the following table:

Pot No.	MATERIALS APPLIED.	Air dried in laboratory for several weeks under like conditions. Grams of grain.	Grams of straw.	Grams of straw and grain from the two pots.	Dried at 100° C. Grams of straw and grain from the two pots.
82 ..	1.7046 grams, nitrate of soda and	5.29	12.70	35.14	31.48
83 ..	3.4092 " dissolved boneblack	4.67	12.48		
84 ..	1.7046 " nitrate of soda and	5.71	9.00	23.07	20.84
85 ..	1.3637 " muriate of potash	1.61	6.75		
86 ..	1.3637 " muriate of potash and	2.79	6.79	18.74	17.01
87 ..	3.4092 " dissolved boneblack	1.99	7.17		
88 ..	1 7046 " muriate of soda, 3.4092 " dissolved boneblack and 1.3637 " muriate of potash,	6.50	13.12	40.56	36.96
89 ..		7.08	13.86		
90 ..	Same as for pots 88 and 89, and in addition 28.9130 grams of calcium carbonate (carbonate of lime).	6.55	16.87	50.98	45 82
91 ..		8.62	18.94		

From the foregoing table it will be seen that much better results were obtained with nitrogen and phosphoric acid (pots 82

and 83) than with nitrogen and potash (pots 86 and 87), and that where potash was added to the nitrogen and phosphoric acid (pots 88 and 89) the increase was but slight. This goes to show that the weights obtained from pot 84 are probably more nearly correct than those from pot 85, for, owing to the fact that the manurial action of nitrogen was greater than that of phosphoric acid, it would be expected that the results from the use of nitrogen and potash (pots 84 and 85) would be greater than those from phosphoric acid and potash (pots 86 and 87). Since there is a reasonable agreement in case of all the other duplicates, it would seem that some exceptional, but unknown, condition must have existed in the case of pot 85.

Comparing the results from the unlimed pots (88 and 89), which received all three of the so-called essential elements, with those which, in addition, were treated with lime, it will be seen that lime materially increased the yield, thus confirming the field test with beets heretofore described.

SUMMARY.

In experiments with beets already conducted in fifteen localities in the State marked benefit from liming has been observed in every case but one. The smallest gain has been 21 per cent., the next smallest 37 per cent., while in the other cases the crop has been practically doubled, or increased several times.

Experiments with barley, in 1896, indicated a more or less general need of lime, but the results were far less marked than with beets. The gain in mangel-wurzels, due to liming, upon the farm of J. F. James, at Moosup Valley, this season, amounted to about eighteen tons per acre.

With but one or two exceptions the most striking benefit from liming has been noticeable, in 1897, in connection with both red clover and Timothy (*Phleum pratense*) in various sections of the State. In view of the importance of clover, on account of its ability to make use of atmospheric nitrogen and of its feeding

value for stock, lessening, as it does, the necessity for buying so large an amount of cotton seed, linseed, gluten meal, etc., those farmers in Rhode Island who have failed to make it grow successfully, should not neglect to see if their land needs liming.

Since liming increases the relative amount of Timothy in mixtures of that grass with redtop, and also the total weight of the hay crop on so many soils, the attention of all who desire to produce good "horse hay" should be called to the desirability of finding out, likewise, without delay, if their land needs lime. It is an important feature that not only the total crop is increased by liming but the selling price per ton of hay is greater when Timothy, rather than redtop, predominates.

The soil test upon the farm of Benjamin Barton, at Barton's Corner, three miles west of East Greenwich village, indicated a need of lime, also a very marked deficiency of phosphoric acid, followed in order by nitrogen and potash.

The soil test upon the farm of S. D. Stone, about two miles east of Apponaug, upon the Warwick Plain, indicated a great deficiency of lime, and the pot test with the same soil showed a marked deficiency of nitrogen, followed closely by phosphoric acid and potash. This soil was exceptionally light and sandy and deficient in humus, which readily explains why it needs nitrogen more than phosphoric acid. Practically all of the reasonably heavy soils, and particularly such as are well supplied with humus, have been found to be less in need of nitrogen than of phosphoric acid.

THE FIFTH YEAR'S OBSERVATION UPON THE GROWTH OF PLANTS UPON AN ACID UPLAND SOIL, LIMED AND UNLIMED.

H. J. WHEELER AND JOS. A. TILLINGHAST.

During the five years in which this experiment has been in progress, more than one hundred varieties of plants have been tested for the purpose of ascertaining the influence of acid soil upon their growth and the probable degree of benefit derived by each from liming.

The detailed records of these observations are to be found in the reports of this Station for previous years.[1] The work has been conducted upon the permanent experimental plots, Nos. 23, 25, 27 and 29. Like quantities of potash and of phosphoric acid have been applied annually to each of these plots, in the form of muriate of potash, and of dissolved boneblack. Like quantities of nitrogen have also been applied annually to each plot,[2] that upon plots 23 and 25, having always been in the form of sulfate of ammonia, and that upon plots 27 and 29 in the form of nitrate of soda.

Prior to 1895 no applications of magnesia had been made, but in that year magnesum sulphate (Epsom salts) was applied to each plot, at the rate of 200 pounds per acre, and in 1896 and 1897, at the rate of 400 pounds per acre.

In 1893, plots 25 and 29 were treated with air-slacked lime, at

[1] Sixth An. Rpt. (1893), pp. 224-252; Seventh An. Rpt. (1894), pp. 152-167; Eighth An. Rpt. (1895), pp. 205-214: and Ninth An. Rpt. (1896), pp. 242-272.

[2] The total amount of nitrogen was reduced, in 1897, on account of the fruit trees, to one-third the quantity formerly used.

the rate of 5,400 pounds per acre, and again in 1894 at the rate of 1,000 pounds per acre, since which time no further application has been made.

The grasses in connection with which observations have been made this season were sown in the spring of 1895. After they were harvested and weighed for the first time, the plots were kept closely cut with a lawn mower for the remainder of the season. In 1896 the grasses were carefully harvested and weighed, and in some cases assorted, in order to gain an idea of the relative development of certain grasses and weeds upon limed and unlimed soil. After the first cutting they were kept mown close to the ground for the remainder of the year.

The growth in 1897 was not quite as vigorous as in 1896, probably due to the fact that the manurial substances were of necessity applied unusually late, or after the grass was too far advanced to expect to obtain a maximum effect.

The strawberries, which failed to grow upon two of the plots in the spring of 1896, were replaced by potted plants in August of that year, one row each, of three different kinds, having been set across the four plots. The yield of fruit, in 1897, was small, as was expected, but the weights of the same were recorded and will be given farther on. During the year the runners were removed at occasional intervals, always, however, on the same day, and the total length of runners obtained from each of the four plots in the first cuttings has been carefully recorded, in order to give an idea of the relative growth of the plants upon the limed and unlimed plots.

The blackberry, red and black-cap raspberry plants, and gooseberry bushes, and also the missing members among the fruit and forest trees, were all replaced in the spring of 1897.

This was done in such a way as to maintain as uniform conditions upon each plot as possible. For example, enough trees or bushes were removed to make the number upon each plot like that upon the one where the greatest number had died. A like number of the removed members were now reset upon each

plot, provided they were sufficiently uniform, and the balance of each plot was set with new stock of the same variety.

A few miscellaneous garden crops were experimented with in 1897, the details in regard to which will be given later in connection with the recorded results.

Owing to the many explanatory notes involved, and the varied character of the plants under experiment, it is proposed to give the results individually or in groups, according to the necessities of the case.

EXPERIMENT WITH GRASSES.

SWEET VERNAL GRASS, *Anthoxanthum odoratum, L.*

Owing to the failure, in 1896, of the sweet vernal grass, which was sown in the spring of 1895, the section occupied by it upon each of the four plots was reseeded in the spring of 1897. The growth was fair, and, when cut, the herbage was found to contain, practically no weeds nor other grasses. The weights of undried grass were as follows: (*Fig. 2.*)

		Pounds.
23.	Unlimed sulfate of ammonia plot	3.7
25.	Limed " " " "	6.1
27.	Unlimed nitrate of soda plot	7.7
29.	Limed " " " "	9.2

MEADOW OAT GRASS, *Avena elatior, L.*

The herbage on each plot consisted chiefly of meadow oat grass, with traces of meadow soft grass and some orchard-grass. The stand seemed fairly uniform except that there was less orchard-grass on the unlimed sulfate of ammonia plot (23) than on the others. The weights of undried plants of all kinds were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	13.5
25.	Limed " " " "	11.5
27.	Unlimed nitrate of soda plot	12.5
29.	Limed " " " "	16.8

KENTUCKY BLUE-GRASS, *Poa pratensis, L.*

On the unlimed sulfate of ammonia plot (23), there was practically no Kentucky blue-grass. Redtop was present to about the same extent as common or soft rush (*Juncus effusus, L.*), and the two made up the chief portion of the herbage. Some common sorrel and a few miscellaneous weeds were also present.

Upon the limed sulfate of ammonia plot (25) the growth was poor, though the plants consisted chiefly of Kentucky blue-grass. The balance of the herbage comprised traces of redtop, a few small plants of common rush, some common sorrel, and a few miscellaneous weeds.

Upon the unlimed nitrate of soda plot (27) the growth was poorer than on plot 25, and there was also less Kentucky blue-grass. Here traces of wood rush (*Luzula campestris, D. C.*), were noticêable. Common rush, common sorrel, and miscellaneous weeds were more prominent on this plot than on plot 25.

Upon the limed nitrate of soda plot (29) there was more and better Kentucky blue-grass than upon any of the other plots. But little common rush was noticeable, and this was very small. Common sorrel and miscellaneous weeds were nearly lacking, but common white clover was quite abundant.

The weights of undried plants of all kinds were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	2.3
25.	Limed " " " "	3.3
27.	Unlimed nitrate of soda plot	4.3
29.	Limed " " " "	7.0

SHEEP'S FESCUE, *Festuca ovina, L.*

Common rush was noticeable upon all of the plots.

The growth upon the unlimed nitrate of soda plot (27) seemed to be poorest of all. That upon the unlimed and limed (23 and 25) sulfate of ammonia plots was nearly alike, while the best growth resulted upon the limed nitrate of soda plot (29). Some

common white clover was found on both nitrate of soda plots, but a much larger quantity was noticeable upon the limed one (29). More miscellaneous weeds were present upon the unlimed nitrate of soda plot than upon any of the others.

The weights of undried plants of all kinds were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	8.3
25.	Limed " " " "	8.5
27.	Unlimed nitrate of soda plot	5.3
29.	Limed " " " "	12.5

VELVET GRASS, *Holcus lanatus*, *L.*

The herbage upon all four plots consisted of practically nothing but velvet grass, (sometimes called meadow soft grass). The field observations in regard to the appearance of the grass upon the several plots were in accord with the weights obtained. The following are the weights of undried grass upon the several plots:

		Pounds.
23.	Unlimed sulfate of ammonia plot	11.8
25.	Limed " " " "	11.0
27.	Unlimed nitrate of soda plot	7.8
29.	Limed " " " "	17.0

TALLER OR MEADOW FESCUE, *Festuca elatior*, *L.*

Upon the unlimed sulfate of ammonia plot (23) the herbage consisted mostly of orchard-grass associated with traces of meadow fescue, some velvet grass, redtop, and Rhode Island bent, and also a little common rush and another species of *Juncus*. The growth was good only in spots.

The herbage upon the limed sulfate of ammonia plot (25) consisted of about equal parts of meadow fescue and orchard-grass, associated with traces of a species of *Bromus*. The growth was good.

Upon the unlimed nitrate of soda plot (27) orchard-grass pre-

dominated, though some meadow fescue, a little Rhode Island bent, and redtop, and traces of a species of *Bromus* were present. The only weeds noticed were traces of two species of rush, like those observed on plot 23. The growth was poor.

There were found on the limed nitrate of soda plot (29) about equal quantities of meadow fescue and orchard-grass, with traces of Rhode Island bent, velvet grass, and a species of *Bromus*.

The weights of undried miscellaneous grasses, etc., harvested, were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	16.8
25.	Limed " " " "	22.8
27.	Unlimed nitrate of soda plot	14.8
29.	Limed " " " "	25.0

These results indicate the favorable action of lime upon the growth of both meadow fescue and orchard grass.

ORCHARD-GRASS, *Dactylis glomerata, L.*

Upon the unlimed sulfate of ammonia plot (23) the herbage consisted chiefly of orchard-grass, with considerable velvet grass, some Rhode Island bent, and a little common rush. The growth was poor.

Upon the limed sulfate of ammonia plot (25) the orchard-grass predominated. There was present, also, a little velvet grass and redtop. The growth was fair.

The field notes in relation to the unlimed nitrate of soda plot (27) were practically the same as those given in connection with the limed sulfate of ammonia plot (25), except that upon plot 27 common rush was noticeable. The growth was poor. The herbage upon the limed nitrate of soda plot (29) was chiefly orchard-grass, with a little velvet grass and traces of other grasses. The growth was fair. The weights of undried miscellaneous grasses, etc., were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	10.8
25.	Limed " " " "	15.9
27.	Unlimed nitrate of soda plot	12.4
29.	Limed " " " "	15.3

Awnless Brome-Grass, *Bromus inermis, L.*

Upon the unlimed sulfate of ammonia plot (23) the chief grass present was awnless brome-grass. There were also present a little redtop, considerable common rush and traces of miscellaneous weeds. The growth was poor.

Aside from a little redtop, awnless brome-grass was the sole representative upon the limed sulfate of ammonia plot (25). Weeds were absent, and the growth of the grass was fair.

Upon the unlimed nitrate of soda plot (27) the only grass present, aside from traces of redtop and velvet grass, was awnless brome grass. Common rush was present, but in less quantity than upon the unlimed sulfate of ammonia plot. The growth seemed also poorer than upon plot 25.

Grasses, other than awnless brome, were not noticed upon the limed nitrate of soda plot (29). Traces of common rush could be observed. The growth seemed to be slightly better than on plot 25.

The weights of undried miscellaneous grasses, etc., were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	9.3
25.	Limed " " " "	9.5
27.	Unlimed nitrate of soda plot	9.0
29.	Limed " " " "	9.5

Rhode Island Bent-Grass, *Agrostis canina, L.*

Upon each of the plots the ground seemed to be fully occupied with Rhode Island bent, excepting a small quantity of redtop, which was about evenly distributed upon all four plots.

The weights of undried grass were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	15.0
25.	Limed " " " "	10.5
27.	Unlimed nitrate of soda plot	13.3
29.	Limed " " " "	18.5

It should be stated that the extreme south end of plot 23, for a few feet only, has always seemed to be more fertile than the remainder of the plot, which factor may have had a bearing upon yield of Rhode Island bent which occupied the extreme south end of the plot.

REDTOP, *Agrostis alba var. vulgaris, Thurb.*

The growth of redtop was good upon each of the four plots. The only other grass noticeable was Timothy, which was present only in small quantities, but was most prominent upon the limed nitrate of soda plot 29.

The following were the weights of undried grass obtained:

		Pounds.
23.	Unlimed sulfate of ammonia plot	17.0
25.	Limed " " " "	14.0
27.	Unlimed nitrate of soda plot	12.5
29.	Limed " " " "	17.5

Since the redtop came next to the Rhode Island bent at the south end of plot 23, it is possible that the extra fertility of that particular spot, may, as explained in the case of that grass, have had some influence upon the results with redtop.

MEADOW FOX-TAIL, *Alopecurus pratensis, L.*

Meadow fox-tail was entirely lacking on the unlimed sulfate of ammonia plot (23), a little was present on the limed sulfate of ammonia plot (25), a trace on the unlimed nitrate of soda plot (27), and on the limed nitrate of soda plot (29) rather more was present than on plot 25. There was a good stand of redtop upon

all of the plots, and traces of other miscellaneous grasses were also discernible.

These observations indicate that lime was helpful to meadow fox-tail.

The undried grass from each plot weighed as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	14.3
25.	Limed " " " "	11.5
27.	Unlimed nitrate of soda plot	12.0
29.	Limed " " " "	15.8

TIMOTHY, *Phleum pratense, L.*

The herbage on the unlimed sulfate of ammonia plot (23) was mostly redtop. But little Timothy was present, and this was exceeded in amount by velvet grass. Other grasses and weeds were absent. The growth was medium. The redtop and Timothy from a given area of the plot were separated from each other, photographed and weighed. (*See illustration, Fig. 4, showing the relative amounts of Timothy and redtop.*)

Upon the limed sulfate of ammonia plot (25) the grass was chiefly Timothy with some redtop and a little velvet grass. Weeds were not present. The growth was good. (*See illustration, Fig. 4, showing the relative amounts of Timothy and redtop.*)

Upon the unlimed nitrate of soda plot (27) there were about equal amounts of Timothy and redtop, and some velvet grass. Weeds were lacking and the growth was fair. (*See illustration, Fig. 4, showing the relative amounts of Timothy and redtop.*)

Upon the limed nitrate of soda plot (29) the grass was mostly Timothy with some redtop and traces of velvet grass. White clover was noticeable, but weeds were absent. The growth was good. (*See illustration, Fig. 4, showing the relative amounts of Timothy and redtop.*)

The weights of undried grass were as follows:

		Pounds.
23.	Unlimed sulfate of ammonia plot	14.1
25.	Limed " " " "	23.8
27.	Unlimed nitrate of soda plot	20.4
29.	Limed " " " "	23.7

The results upon the Timothy sections of the four plots show, in the most striking manner, that where a considerable degree of soil acidity exists, redtop will always gain the ascendency over Timothy in the struggle for existence, but that after liming the reverse is true. This is not only important on account of the fact that the total yield is increased but also for the reason that hay consisting chiefly of Timothy will usually bring $2.00 per ton more in the local markets, than a product which is chiefly redtop. It will be noticed by reference to the illustration (*Fig 4.*) showing the relative amounts of the two grasses upon each of the plots, that liming increased the relative percentage of Timothy where sulfate of ammonia was used, less than where nitrogen in form of nitrate of soda had been applied.

On the unlimed nitrate of soda plot there was also proportionately more Timothy than on the unlimed sulfate of ammonia plot. This may have been due perhaps to some special direct, or indirect manurial function, or to some physical effect upon the soil produced by the soda, which may have affected the Timothy more favorably than the redtop. The more probable explanation seems to be that the difference was due to the reactions of the soil as influenced by residual sulfuric acid in the case of the sulfate of ammonia, and of soda in the case of the nitrate of soda.

Other experiments are in progress, which it is hoped may eventually throw additional light upon these points.

EXPERIMENTS WITH MISCELLANEOUS PLANTS.

ASPARAGUS.

On April 17th, 1897, thirty asparagus plants, one year old, were set out upon each of the four plots. The crowns were set about

four inches deep. On June 28th it was found that seven plants had died on each plot, excepting the unlimed sulfate of ammonia plot (23), upon which nine had died. On that date the average heights of the plants were as follows:

		Inches.
23.	Unlimed sulfate of ammonia plot	3.5
25.	Limed " " " "	9.0
27.	Unlimed nitrate of soda plot	6.7
29.	Limed " " " "	12.7

As the season advanced no other plants died on plots 25, 27 and 29, but upon plot 23 they continued to turn yellow and die, and late in the autumn but one plant seemed alive, and this one was hardly larger than in June. The growth upon the unlimed nitrate of soda plot (27) was far from satisfactory during the entire season, while that upon both of the limed plots was thrifty. Notwithstanding the thrifty appearance of the plants on the limed sulfate of ammonia plot (25), it was very noticeable early in the season, and became more so with its advance, that the plants upon the limed nitrate of soda plot (29) were far superior to them. To what this great advantage of the nitrate of soda over the sulfate of ammonia may have been attributable cannot be stated positively without further experimental work. The difference in the physical effect of the two compounds upon the soil may have exerted some influence. Asparagus has been generally considered as a plant which is particularly in need of soda, since applications of common salt are usually beneficial to it. Some writers, however, urge that the benefit derived from common salt is almost wholly due to its indirect action in liberating potash and possibly other manurial ingredients which were locked up in the soil in such combinations as to be non-assimilable by plants. Many observations in connection with other plants, and particularly with beets, spinach, and lettuce, at this Station, incline one to the conclusion that the soda may possibly have exerted some direct manurial influence upon the growth of the asparagus, but that the difference between the results upon the two limed plots may

have been due to a considerable extent, also, to the difference in the two plots as regards acidity, since, as indicated already in connection with the discussion of the Timothy experiments, the residual sulfuric acid of the sulfate of ammonia would tend to produce greater acidity of the soil, the reverse of the action of the residual soda of the nitrate of soda.

WATERMELONS AND CANTALOUPES.

In 1894, the year when the second application of lime was made, more watermelons were obtained from the limed than from the unlimed sulfate of ammonia plot, but there was a yield of only 160.4 pounds upon the limed nitrate of soda plot as compared with 249.6 pounds upon the unlimed one. The maturity of the crop was, however, hastened by liming. In 1895, after the lime had become more intimately mixed with the soil by further tillage, the following weights of watermelons were obtained:

		Pounds.
23.	Unlimed sulfate of ammonia plot	136.0
25.	Limed " " " "	20.6
27.	Unlimed nitrate of soda plot	104.8
29.	Limed " " " "	57.1

It will be seen from the above that, in 1895, the limed plots produced less in each instance than the unlimed ones. In this instance no noticeable advantage in maturity was apparent on the limed plots, which was probably due to the great retardation of growth induced by the liming.

Cantaloupes and muskmelons have shown an exactly opposite tendency to that exhibited by watermelons, since they have been invariably helped by liming in a marked degree. An attempt was made this season to make another trial of these plants, to see if an ill effect of the lime would still be noticeable in connection with watermelons. Unfortunately, owing to the almost continuous rains, the first lot of cantaloupe and watermelon seeds planted nearly all rotted in the soil without germinating; sub-

sequently they were replanted, but, owing to the excessive moisture and the lateness of the season, they failed to make any considerable growth or to ripen any melons. The only indications that could be afforded of the probable effect of lime, were those obtainable by weighing the unripe fruit produced, which are, therefore, not at all conclusive. The data are given here merely as indicative features and as a matter of record, and not with the expectation that they will be looked upon as at all conclusive. The results are as follows :

		Cantaloupes. Pounds.	Watermelons. Pounds.
23.	Unlimed sulfate of ammonia plot..........	0.0	2.3
25.	Limed " " " "	11.0	4.0
27.	Unlimed nitrate of soda plot.....	6.3	9.8
29.	Limed " " " "...............	18.0	13.0

NEW ZEALAND SPINACH.

Several previous trials of ordinary spinach have always resulted in far greater yields from the limed than from the unlimed plots. Upon the unlimed sulfate of ammonia plot (23) practically all of the spinach plants have invariably died before the end of the season, while such has been the case with usually more than half of those on the unlimed nitrate of soda plot (27). This has been attributed to the intense acidity of the soil. The limed nitrate of soda plot (29) has, without exception, yielded far more spinach than the limed sulfate of ammonia plot, even though the reverse has been true of many ordinary crops in certain seasons. This difference has been attributed to a direct or indirect manurial action of the soda, or to differences in the reaction of the soil caused by the acid tendency of the sulfuric acid in the one case, and of the alkaline action of the soda in the other. To which of these reasons this is attributable, or in what measure to the one or the other, can only be shown by further experiments.

It will be seen, from the following results with New Zealand

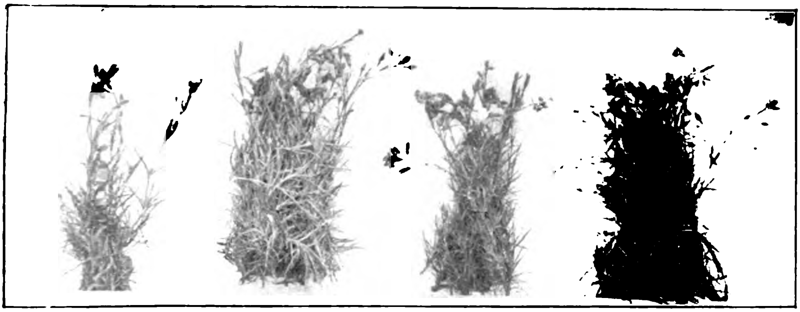


FIG. 1—CARNATION PINKS.

Plot 23. *Unlimed.* Plot 25. *Limed.* Plot 27. *Unlimed.* Plot 29. *Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash and phosphoric acid.

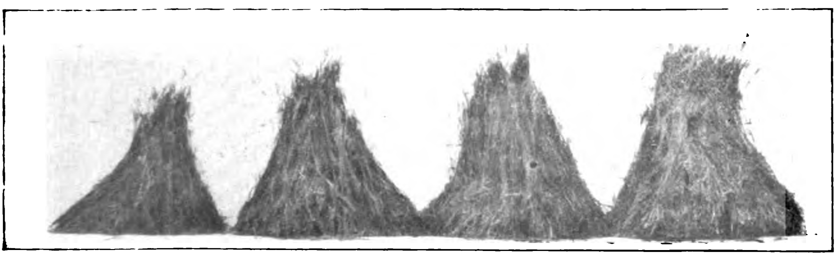


FIG. 2.—SWEET VERNAL-GRASS.

Plot 23. *Unlimed.* Plot 25. *Limed.* Plot 27. *Unlimed.* Plot 29. *Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash and phosphoric acid.

Fig. 3.—New Zealand Spinach.

Plot 23. Plot 25 Plot 27. Plot 29.
Unlimed. *Limed.* *Unlimed.* *Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash and phosphoric acid.

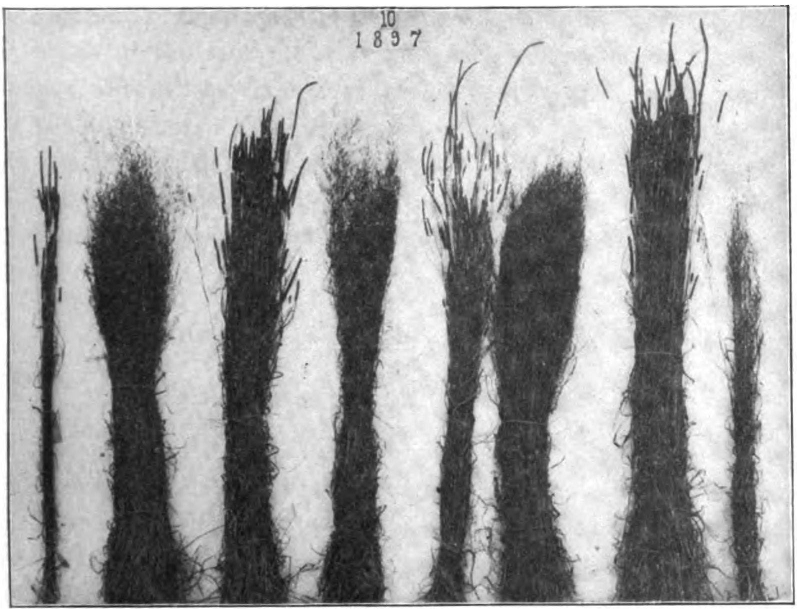


Fig. 4.—Showing the relative development of Timothy and redtop on limed and unlimed soil.

1 2 3 4 5 6 7 8

The odd numbers represent Timothy and the even ones redtop.

Plot 23. Plot 25. Plot 27. Plot 29.
Unlimed. *Limed.* *Unlimed.* *Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash and phosphoric acid.

spinach, that it is similar, in all of the particulars enumerated above, to ordinary spinach. (*See illustration, Fig. 3.*)

		Pounds.
23.	Unlimed sulfate of ammonia plot	1.0
25.	Limed " " " "	37.8
27.	Unlimed nitrate of soda plot	10.8
29.	Limed " " " "	52.5

CARNATION PINKS.

In view of many inquiries which have come to the Station in regard to the action of lime upon the growth of carnations, and, in consideration of its use by many growers of these plants, it was thought desirable to make a few tests with them. Accordingly a like number of plants of three standard varieties was set out upon each of the four plots. Since each variety seemed to be similarly affected by lime, the three were weighed and photographed together. (*See illustration, Fig. 1.*) When set out in the spring the cuttings were well rooted and very uniform in size. The following were the weights of the plants, taken at about the time when they are usually transferred from the field to the greenhouse:

		Pounds.
23.	Unlimed sulfate of ammonia plot	0.4
25.	Limed " " " "	1.7
27.	Unlimed nitrate of soda plot	0.7
29.	Limed " " " "	1.3

A marked benefit from liming was noticeable in connection with both forms of nitrogen. The plants upon the limed sulfate of ammonia plot looked rather more vigorous than those upon the limed nitrate of soda plot in full agreement with the observed differences in the weights of the two lots. This may have been due to some specific action of the sulfuric acid in the one case or of soda in the other. A very reasonable explanation is that the nitrate of soda, due to the heavy rains, may have leached more than the sulfate of ammonia, on which account there was more

nitrogen at the disposal of the plant where the latter compound of nitrogen was applied.

OBSERVATIONS UPON SMALL FRUITS.

Strawberries.

In the spring of 1896 strawberry plants were set out upon each of the four plots, but as nearly all of them died upon the sulfate of ammonia plots, and many, also, upon the others, they were replaced in August of that year, by potted plants. In all, three rows of plants were set out. The Chas. Downing variety was set in the south row, and Lady Rusk in the north one, with the Haverland between.

The runners were removed at occasional intervals, and those taken from the plants at the first two cuttings were measured, in order to give an idea of the growth of the vines. The results of these measurements are as follows:

Measurements of Runners.

Varieties.	Sulfate of Ammonia.		Nitrate of Soda.	
	Plot 23. Unlimed.	Plot 25. Limed.	Plot 27. Unlimed.	Plot 29. Limed.
	Inches.	Inches.	Inches.	Inches.
Measured June 22, 1897.				
Lady Rusk	24.0	403.0	240.5	369.5
Haverland	8.0	248.0	327.0	156.5
Chas. Downing	242 5	380.0	512.0	981.0
Measured July 26, 1897.				
Lady Rusk	896.0	665.0	798.0	834.0
Haverland	509.0	898.0	1,198.0	1,809.0
Chas. Downing	1,692.0	1,127.0	2,338.0	2,590.0

In the case of the first cutting there was a much greater total length of runners, with all three varieties, upon the limed, than upon the unlimed sulfate of ammonia plot. Upon the nitrate of soda plots there was a greater total length of runners upon the limed than upon the unlimed one in the case of the Lady Rusk and Chas. Downing, while the reverse was true of the Haverland.

At the second cutting the Haverland only, showed a greater total length of runners upon the limed than upon the unlimed sulfate of ammonia plot, the reverse being true of the Lady Rusk and Chas. Downing. Upon the nitrate of soda plots all three varieties showed more runners upon the limed than upon the unlimed plot.

The observations, though conflicting in a measure, point in the main to a greater development of runners upon the limed than upon the unlimed plots.

The plants when set out were not very large, owing to their having been potted for too short a time, and for this reason they were not in condition to produce a heavy crop in 1897. Notwithstanding this fact it was thought desirable to harvest and weigh the fruit. The following are the data obtained:

Total Weights of Strawberries (in grams).

VARIETIES.	Sulfate of Ammonia.		Nitrate of Soda.	
	Plot 23. Unlimed.	Plot 25. Limed.	Plot 27. Unlimed.	Plot 29. Limed.
Lady Rusk	62.4	264.9	242.2	203.7
Haverland	58.3	370.2	237 6	351.1
Chas. Downing	15.2	312.3	351.0	519.3

From the above table it will be seen that, with one exception, the yields of fruit were greater in every case upon the limed than upon the unlimed nitrate of soda plot.

Currants and Gooseberries.

Since the currant and gooseberry bushes fruited in 1897 for the first time, the yields, particularly of the former, were small. They were as follows:

Total Weights of Currants (in grams)

Varieties.	Sulfate of Ammonia.		Nitrate of Soda.	
	Plot 23. Unlimed.	Plot 25. Limed.	Plot 27. Unlimed.	Plot 29. Limed.
Fay's Prolific (red currant)......	9.0	31.5	28.5	89.6
White Dutch (white currant)....... ..	253.7	281.0	304.5	352.6
Smith's Improved (gooseberry)........	88.0	1,505.0	1,428.0	1,614.0

From the above table it will be seen that the results for the first season indicate that both currants and gooseberries are helped by liming upon the soil which is decidedly acid. More conclusive data should be obtainable in succeeding seasons after the bushes have become sufficiently large to produce maximum crops.

Raspberries and Blackberries.

Neither the black-cap nor red raspberries (Cuthbert), nor the blackberries fruited sufficiently in 1897 to make any records in relation to that point desirable.

In a general way it may be stated that liming seemed to be beneficial to the two varieties of raspberries, and either slightly injurious or at least not noticeably beneficial to the blackberry. It is hoped that observations in 1898 may furnish some positive data in relation to these fruits.

Grapes.

The observations upon grapes have been confined exclusively to the Concord and Delaware varieties. Measurements of the total length of the new growth for the year 1896 were made and re-

corded in the annual report of the Station for that year. Similar measurements have been made in 1897. As soon as the vines are sufficiently large, it is hoped also to determine the effect of liming upon the yield of fruit.

Length of new Growth of Grape-vines in 1897 (inches).

VARIETY OF GRAPE.	Number of Vine.	SULFATE OF AMMONIA. Plot 23. Unlimed.	SULFATE OF AMMONIA. Plot 25. Limed.	NITRATE OF SODA. Plot 27. Unlimed.	NITRATE OF SODA. Plot 29. Limed.
Delaware	1	7	Dead.	Dead.	606
"	2	15	192	72	680
"	3	4	290	210	156
"	4	14	410	298	403
"	5	113	421	110	273
Total length	....	153	1,313	685	2,118
Average length	....	30.6	328.3	171.3	423.6
Concord	1	80	618	902	673
"	2	186	805	973	970
"	3	.164	944	929	1,373
"	4	268	684	1,312	757
"	5	418	1,539	756	1,037
Total length	....	1,116	4,590	4,872	4,810
Average length	....	223.2	918.0	974.4	962.0

It will be seen that there is considerable variation in the results due to unavoidable individuality of the vines, but the observations indicate some benefit from liming in connection with the Concord variety, while the Delaware seems to be particularly liable to in-

jury by acidity of soils, and to stand, therefore, much more in need of carbonate of lime. This may serve as a new factor in part explanation of the failure of the Delaware in certain localities where the Concord succeeds fairly well.

OBSERVATIONS UPON QUINCE BUSHES AND WITH ORCHARD AND FOREST TREES.

The observations upon fruit and forest trees are a continuation of those begun in 1896, a description of which is given in the Ninth Annual Report of this Station. Since none of them were large enough to bear fruit in 1897, measurements of their growth have been made by observing the increase in their butt diameters during the year. No attempt has been made this season to measure the total length of new growth, since the enormous number of new branches would have rendered it too great an undertaking.

Table showing the Diameters of the Trees and Bushes (in centimeters) at the Beginning and End of the Season of 1897.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms.)

Name of Bush or Tree.	Tree or Bush Number.	Sulfate of Ammonia.						Nitrate of Soda.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.	Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.	Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.	Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.
Orange quince.....	1	1.4	1.6	0.2	1.9	3.1	1.2	1.8	2.5	0.7	1.8	2.5	0.7
	2	1.2	1.2	0.0	1.8	2.2	0.4	1.7	1.9	0.2	1.7	2.5	0.8
	3	1.0	1.2	0.2	1.7	2.3	0.6	1.7	2.3	0.6	1.8	2.7	0.9
	4	1.3	1.6	0.3	2.0	2.3	0.3	1.5	2.0	0.5	1.6	2.4	0.8
	5	2.0	2.1	0.1	1.8	2.5	0.7	1.7	2.2	0.5	1.4	2.2	0.8
Total........	....	6.9	7.7	0.8	9.2	12.4	3.2	8.4	10.9	2.5	8.3	12.3	4.0
Ave'ge diam.	....	1.38	1.54	0.16	1.84	2.48	0.64	1.68	2.18	0.5	1.66	2.46	0.8
Bartlett Pear	1	1.0	1.0	0.0	1.2	1.6	0.4	1.1	1.7	0.6	1.4	1.8	0.4
	2	1.5	1.9	0.4	1.2	1.6	0.4	1.6	3.0	1.4	1.2	2.0	0.8
	3	1.3	1.7	0.4	1.3	2.6	1.3	1.7	2.2	0.5	1.4	2.5	1.1
	4	1.5	1.8	0.3	1.7	2.7	1.0	1.4	2.2	0.8	1.4	2.4	1.0
	5	1.5	2.7	1.2	1.2	1.7	0.5	1.1	1.2	0.1	1.2	2.1	0.9
Total........	....	6.8	9.1	2.3	6.6	10.2	3.6	6.9	10.3	3.4	6.6	10.8	4.2
Ave'ge diam.	....	1.36	1.82	0.46	1.32	2.04	0.72	1.38	2.06	0.68	1.32	2.16	0.84
Early Crawford peach.	1	2.1	2.9	0.8	3.1	6.0	2.9	2.7	5.1	2.4	2.5	4.5	2.0
	2	1.9	3.1	1.2	2.8	5.4	2.6	2.7	6.0	3.3	2.4	4.5	2.1
	3	2.4	4.4	2.0	2.2	2.2	0.0	2.5	5.8	3.3	2.6	4.5	1.9
	4	2.5	4.5	2.0	2.5	4.6	2.1	2.2	4.3	2.1	2.5	4.6	2.1
	5	2.6	4.2	1.6	2.7	4.5	1.8	2.0	4.2	2.2	2.7	4.9	2.2
Total........	....	11.5	19.1	7.6	13.3	22.7	9.4	12.1	25.4	13.3	12.7	23.0	10.3
Ave'ge diam.	....	2.30	3.82	1.52	2.7	4.54	1.88	2.42	5.08	2.66	2.54	4.6	2.06

Table showing the Diameters of the Trees and Bushes (in centimeters)—Continued.

NAME OF BUSH OR TREE.	Tree or Bush Number.	SULFATE OF AMMONIA. Plot 23.—*Unlimed.* Diameter in Spring of 1897.	Plot 23.—*Unlimed.* Diameter in Fall of 1897.	Plot 23.—*Unlimed.* Increase in diam.	Plot 25.—*Limed.* Diameter in Spring of 1897.	Plot 25.—*Limed.* Diameter in Fall of 1897.	Plot 25.—*Limed.* Increase in diam.	NITRATE OF SODA. Plot 27.—*Unlimed.* Diameter in Spring of 1897.	Plot 27.—*Unlimed.* Diameter in Fall of 1897.	Plot 27.—*Unlimed.* Increase in diam.	Plot 29.—*Limed.* Diameter in Spring of 1897.	Plot 29.—*Limed.* Diameter in Fall of 1897.	Plot 29.—*Limed.* Increase in diam.
Golden sweet apple..	1	1.7	2.3	0.6	1.7	2.7	1.0	1.9	3.3	1.4	2.4	3.5	1.1
	2	1.8	2.8	1.0	1.5	2.4	0.9	1.7	3.0	1.3	2.3	4.4	2.1
	3	2.0	3.3	1.3	1.7	3.0	1.3	1.7	2.9	1.2	1.9	3.0	1.1
	4	1.7	2.4	0.7	1.8	2.9	1.1	1.8	3.3	1.5	2.1	3.3	1.2
	5	1.8	3.6	1.8	1.8	3.0	1.2	1.7	3.1	1.4	1.6	2.5	0.9
Total........	....	9.0	14.4	5.4	8.5	14.0	5.5	8.8	15.6	6.8	10.3	16.7	6.4
Ave'ge diam.	....	1.8	2.88	1.08	1.70	2.80	1.10	1.76	3.1	1.36	2.06	3.34	1.28
Baldwin apple......	1	1.8	2.2	0.4	1.9	3.4	1.5	1.8	3.0	1.2	1.8	3.4	1.6
	2	1.8	2.7	0.9	1.7	2.8	1.1	1.8	3.5	1.7	1.8	3.5	1.7
	3	1.5	1.9	0.4	2.0	3.5	1.5	1.9	4.0	2.1	1.9	4.1	2.2
	4	2.0	3.6	1.6	1.6	2.6	1.0	1.9	3.6	1.7	1.5	2.3	0.8
	5	2.1	3.8	1.7	2.0	3.6	1.6	1.9	3.6	1.7	2.0	3.7	1.7
Total........	....	9.2	14.2	5.0	9.2	15.9	6.7	9.3	17.7	8.4	9.0	17.0	8.0
Ave'ge diam.	....	1.84	2.84	1·0	1.84	3.18	1.34	1.86	3.54	1.68	1.80	3.40	1.60
Sugar maple.	1	1.1	1.3	0.2	1.0	1.4	0.4	*	1.7*	*	0.8	1.1	0.3
	2	1.2	1.2	0.0	*	1.6*	*	1.2	1.7	0.5	0.9	1.7	0.8
	3	1.2	1.3	0.1	0.9	1.1	0.2	0.9	1.2	0.3	0.8	1.5	0.7
	4	1.1	1.2	0.1	*	2.0*	*	1.0	1.5	0.5	1.2	1.5	0.3
	5	1.1	1.2	0.1	1.0	1.4	0.4	1.0	1.4	0.4	1.2	1.5	0.3
	6	1.3	1.4	0.1	1.1	1.6	0.5	*	1.4*	*	1.2	1.5	0.3
	7	1.1	1.1	0.0	*	1.5*	*	0.7	1.3	0.6	1.3	1.4	0.1
	8	1.1	1.3	0.2	0.9	1.4	0.5	1.1	1.2	0.1	1.1	1.4	0.3
	9	0.9	1.2	0.3	0.7	1.3	0.6	1.2	1.7	0.5	1.3	1.6	0.3
Total.... ...	....	10.1	11.2	1.1	5.6	8.2	2.6	7.1	10.0	2.9	9.8	13.2	3.4
Ave'ge diam.	....	1.12	1.22	0.12	0.93	1.37	0.43	1.0	1.43	0.41	1.10	1.47	0.37

* Reset in spring of 1897 and not measured until growth ceased the following autumn, and consequently omitted from averages.

Table showing the Diameters of the Trees and Bushes (in centimeters)—Continued.

NAME OF BUSH OR TREE.	Tree or Bush Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 25.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.	Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.	Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.	Diameter in Spring of 1897.	Diameter in Fall of 1897.	Increase in diam.
American elm	1	2.0	3.0	1.0	2.1	3.5	1.4	2.9	4.4	1.5	2.5	4.7	2.2
	2	1.8	2.7	0.9	2.5	4.0	1.5	2.6	4.5	1.9	2.8	5.7	2.9
	3	1.9	2.2	0.3	1.8	3.8	2.0	2.0	3.4	1.4	2.6	5.2	2.6
	4	1.9	2.2	0.3	3.0	5.2	2.2	2.3	3.9	1.6	2.8	4.6	1.8
	5	2.1	2.4	0.3	2.4	4.0	1.6	2.0	3.0	1.0	2.4	4.7	2.3
	6	2.3	2.9	0.6	2.1	3.5	1.4	2.9	3.9	1.0	2.3	3.5	1.2
	7	1.7	2.4	0.7	2.5	4.9	2.4	2.3	4.4	2.1	2.2	4.2	2.0
	8	2.4	3.7	1.3	2.4	3.6	1.2	1.9	3.4	1.5	2.0	3.7	1.7
	9	2.3	3.8	1.5	2.2	4.1	1.9	2.5	4.4	1.9	2.6	5.2	2.6
Total	....	18.4	25.3	6.9	21.0	36.6	15.6	21.4	35.3	13.9	22.2	41.5	19.3
Ave'ge diam.	....	2.04	2.81	0.77	2.33	4.07	1.73	2.38	3.92	1.54	2.47	4.62	2.14
American white birch	1	1.5	1.5	0.0	*	1.9*	*	1.6	1.6	0.0	1.8	3.1	1.3
	2	1.8	2.8	1.0	1.9	1.9	0.0	*	1.8*	*	2.0	3.6	1.6
	3	1.5	1.7	0.2	*	1.9*	*	1.4	2.7	1.3	2.3	2.3	0.0
	4	*	1.9*	*	1.5	2.7	1.2	*	2.1*	*	*	1.8*	*
	5	1.4	3.5	2.1	*	1.5*	*	1.3	2.9	1.6	1.9	1.9	0.0
	6	*	1.6*	*	1.8	2.1	0.3	*	1.9*	*	*	1.8*	*
	7	1.6	2.7	1.1	1.5‡	0.3†	....	1.7	3.5	1.8	*	1.7*	*
	8	*	1.8*	*	2.3	2.9	0.6	1.9	3.0	1.1	*	1.9*	*
	9	*	1.2*	*	1.7	2.4	0.7	*	2.1*	*	1.7	3.1	1.4
	10	*	1.4*	*	*	2.0*	*	1.9	2.1	0.2	1.9	3.0	1.1
Total	....	7.8	12.2	4.4	9.2	12.0	2.8	9.8	15.8	6.0	11.6	17.0	5.4
Ave'ge diam.	....	1.56	2.44	0.88	1.84	2.4	0.56	1.63	2.63	1.0	1.93	2.83	0.9

* Reset in spring of 1897 and not measured until growth ceased the following autumn, and consequently omitted from the averages.

† A sprout from the original tree, the main stalk having died. Omitted from averages.

‡ Omitted from averages.

Table showing the Diameters of the Trees and Bushes (in centimeters)—Continued.

NAME OF BUSH OR TREE.	Tree or Bush Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in June, 1896.	Diameter in Fall of 1897	Increase in diam.	Diameter in June, 1896.	Diameter in Fall of 1897.	Increase in diam.	Diameter in June, 1896.	Diameter in Fall of 1897.	Increase in diam.	Diameter in June, 1896.	Diameter in Fall of 1897.	Increase in diam.
American linden......	1	1.3	1.7	0.4	1.4	3.1	1.7	1.5	2.3	0.8	1.6	2.9	1.3
	2	1.6	2.1	0.5	1.4	2.7	1.3	1.4	3.3	1.9	1.3	2.5	1.2
	3	1.3	1.7	0.4	1.3	3.0	1.7	1.2	2.5	1.3	1.4	2.6	1.2
	4	1.4	1.9	0.5	1.4	3.7	2.3	1.7	3.4	1.7	1.5	3.0	1.5
	5	1.6	2.4	0.8	1.4	2.5	1.1	1.4	2.2	0.8	1.2	2.2	1.0
	6	1.8	2.9	1.1	1.6	3.1	1.5	1.7	2.2	0.5	1.2	2.5	1.3
	7	1.4	2.1	0.7	1.2	2.6	1.4	1.6	2.9	1.3	1.3	2.6	1.3
	8	1.9	2.6	0.7	1.8	3.7	1.9	1.2	2.9	1.7	1.6	2.4	0.8
	9	1.6	2.2	0.6	1.7	2.7	1.0	1.2	1.8	0.6	1.9	3.9	2.0
Total........	....	13.9	19.6	5.7	13.2	27.1	13.9	12.9	23.5	10.6	13.0	24.6	11.6
Ave'ge diam.	....	1.54	2.18	0.63	1.46	3.01	1.54	1.43	2.61	1.18	1.44	2.73	1.29

SUMMARY.

In brief it may be stated that, of all the grasses thus far tested, none seemed to stand so much in need of lime on acid soil as Kentucky blue-grass and Timothy.

Orchard-grass and meadow fescue, though less injured by soil acidity (sourness) than Kentucky blue-grass or Timothy, nevertheless show great benefit from liming. Sheep's fescue is also benefited by liming to a considerable extent, though it gives no promise of value for hay in this section.

Awnless brome-grass, redtop and Rhode Island bent, though valuable grasses, do not seem to be susceptible of great injury, even upon quite acid soils. This observation furnishes a satisfactory explanation of the fact that Timothy and clover give way rapidly to redtop and Rhode Island bent on many of our New

England farms. Those who have such experiences as this should lose no time in testing their soils by the use of ammonia water and blue litmus paper, followed by trials of lime wherever any considerable acidity or sourness of soil is noticed.

This season's trial indicates wonderful benefit from the use of lime in the growing of asparagus. These observations are to be continued if possible.

New Zealand spinach, like the ordinary varieties, seems to be much helped by liming.

Spinach and asparagus give much better results from nitrogen in form of nitrate of soda than from like quantities in form of sulfate of ammonia. Experiments are in progress for the purpose of ascertaining definitely, if possible, to what this difference is due.

Strawberries, currants and gooseberries have shown this season some benefit from liming, yet it will be necessary to wait a year or two before definite conclusions in the matter can be drawn.

Judging from the growth only, raspberry plants appear to show some benefit from liming, while no noticeable differences in blackberry plants have been observable.

Delaware grape-vines seem to be injured in a marked degree by sour soil, and correspondingly helped by liming, while the Concord vines appear to be comparatively indifferent in this particular.

Among the other tests made the past season the orange quince, golden sweet apple, American elm and American linden show more probability of ultimate benefit from liming than the Crawford's early peach, Baldwin apple, Bartlett pear, sugar maple or American white birch. In future years more conclusive data should be obtainable in relation to the small fruits, orchard and forest trees.

ON THE SUBSTITUTION OF SODA FOR AND ITS VALUE IN CONNECTION WITH POTASH.

H. J. WHEELER AND J. A. TILLINGHAST.

The chief experiment herein described is a continuation of that begun in 1894, the details of which in previous years may be found in the Seventh Annual Report of this Station (1894), pp. 168–182; the Eighth Annual Report (1895), pp. 215–231; and in the Ninth Annual Report (1896), pp. 221–241.

Each year a generous and equal application of nitrogen and phosphoric acid has been made to each plot. Dried blood has served as the form of nitrogen from the outstart, while phosphoric acid has been applied in several forms. In 1895 and 1896 magnesia in the form of magnesium sulfate, (Epsom salts) was applied to each plot, so that, if a beneficial effect were noticed from the use of soda, there would be little or no ground for attributing this to its having liberated magnesia, and thus having furnished indirectly a plant food. In 1894 certain series of the plots received air-slacked lime at the rate of two tons per acre, no further application of it having been made to them until 1896, when they were again dressed at the rate of 1,200 pounds per acre. In 1897 no lime was applied.

The full ration of sodium carbonate has been made such each year that it would neutralize the same amount of acid as the full ration of potassium carbonate. Owing to the influence of acidity and alkalinity upon the growth of certain plants it seemed desirable, so far as concerned the manurial substances applied, to maintain like conditions in this particular rather than to employ like

weights of each salt regardless of their relative alkalinity. In the case of the potassium and sodium chlorids the quantities employed were such as to furnish the same amounts of potassium and sodium respectively as were represented by the potassium and sodium carbonates.

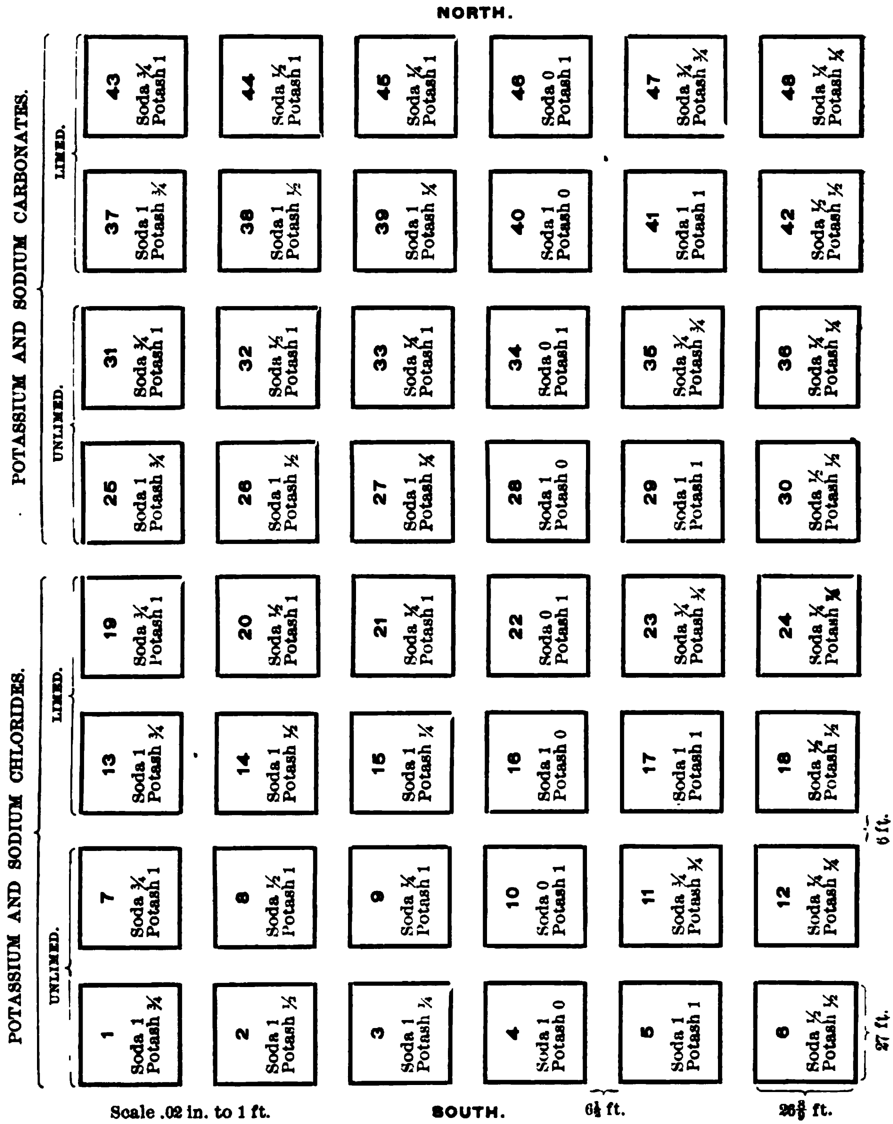
In 1897 dried blood was applied at the rate of 1,020 pounds per acre, dissolved boneblack at the rate of 600 pounds, floats at the rate of 480 pounds, and sulfate of magnesia at the rate of 420 pounds per acre. The foregoing ingredients were applied at uniform rates to each of the forty-eight plots.

The full ration of potassium carbonate was 360 pounds per acre (6 pounds per plot), that of sodium carbonate 244.8 pounds per acre (4.08 pounds per plot), that of muriate of potash 413.4 pounds per acre (6.89 pounds per plot), and that of sodium chlorid (common salt) 277.2 pounds per acre (4.62 pounds per plot). The subjoined diagram shows not only the size and arrangement of the plots but also the fractional parts of the "full" rations of potassium and sodium salts which were applied to each. The diagram also shows which of the plots were limed.

The fertilizer was spread broadcast upon the surface and then thoroughly cultivated in.

The first two years of the experiment certain plants were grown which, in other experiments, have given no indication, on our soil, of having been benefited by soda, and also others which had, on the contrary, given indications that soda was useful to them. Having obtained two years' observations with both classes of plants at the outstart, an attempt was then made to exhaust the natural supply of potash in the soil as rapidly as possible. In order to effect this it was planned to grow two crops per year for two or three years and then make a trial again of the two classes of plants experimented with at first. In pursuance of this plan oats were followed by millet in both 1896 and 1897. In neither season was a marked difference noticeable in the first crop. Either the millet has less capacity for gathering its potash from the soil, or else the oat crop so far exhausted the potash which

PLAN SHOWING THE ARRANGEMENT OF THE PLOTS AND THE KINDS OF FERTILIZING MATERIAL APPLIED TO EACH.



PLAN OF PLOTS CORRESPONDING TO THAT ON PAGE 228, SHOWING THE POUNDS OF OAT AND MILLET FODDER (WEIGHED GREEN) PER PLOT.

[*In the diagram O=oats and M=millet.*]

POTASSIUM AND SODIUM CHLORIDS.				POTASSIUM AND SODIUM CARBONATES.			
UNLIMED.		LIMED.		UNLIMED.		LIMED.	
1 O...345.0 M...130.0	7 O...330.0 M...125.0	13 O...360.0 M...195.0	19 O...350.0 M...185.0	25 O...270.0 M...135.0	31 O...280.0 M...145.0	37 O...305.0 M...215.0	43 O...315.0 M...225.0
2 O...350.0 M...112.5	8 O...360.0 M...145.0	14 O...365.0 M...150.0	20 O...355.0 M...147.5	26 O...280.0 M...105.0	32 O...300.0 M...135.0	38 O...290.0 M...145.0	44 O...315.0 M...187.5
3 O...320.0 M...110.0	9 O...335.0 M...140.0	15 O...335.0 M...110.0	21 O...365.0 M...140.0	27 O...260.0 M...105.0	33 O...305.0 M...160.0	39 O...300.0 M...125.0	45 O...340.0 M...200.0
4 O...295.0 M... 42.5	10 O...360.0 M...137.5	16 O...260.0 M... 27.5	22 O...360.0 M...155.0	28 O...210.0 M... 25.0	34 O...305.0 M...147.5	40 O...235.0 M... 80.0	46 O...300.0 M...152.5
5 O...360.0 M...120.0	11 O...225.0 M...110.0	17 O...370.0 M...185.0	23 O...340.0 M...130.0	29 O...275.0 M...135.0	35 O...285.0 M...140.0	41 O...330.0 M...195.0	47 O...300.0 M...152.5
6 O...330.0 M... 97.5	12 O...305.0 M... 97.5	18 O...355.0 M...145.0	24 O...300.0 M... 92.5	30 O...280.0 M...105.0	36 O...285.0 M... 82.5	42 O...285.0 M...152.5	48 O...270.0 M... 95.0

had become assimilable during the winter, spring, and early summer, that the supply remaining was inadequate for another crop, for both seasons the growth of millet was extremely poor upon the plots without, or but inadequately supplied with, potash. These results with millet have shown, conclusively, that sodium cannot be fully substituted for potash. Whether soda can replace potash to any practical extent or not has not yet been shown. If such is the case it may be true only in connection with certain classes of plants, a point which should become clearer just as soon as the soil is sufficiently exhausted of its assimilable potash to permit of a return to experiments with the plants originally tested. (*For illustrations of the millet grown in 1897 see Figs. 1 to 8.*)

The oats were sown on May 10th, and were cut in an unripe condition and weighed green on July 24th. Four days later golden millet was sown upon all of the plots, and this was cut and weighed green on September 28th. It would have been left until later had it not been injured by frost on the night of September 27th. The results with both crops are embodied in the tables which follow:

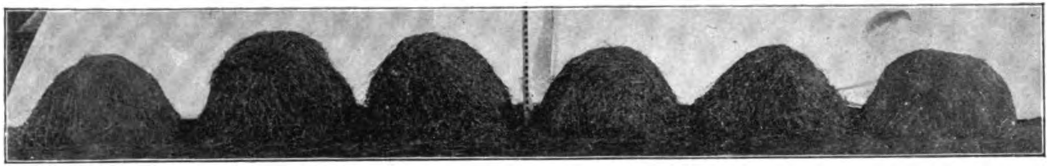


Fig. 1.—Millet.
Potassium and Sodium Chlorids. *Unlimed.*

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¾	¼

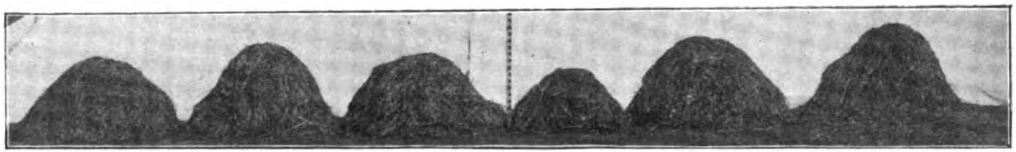


Fig. 2.—Millet.
Potassium and Sodium Chlorids. *Unlimed.*

Potash ration	¾	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

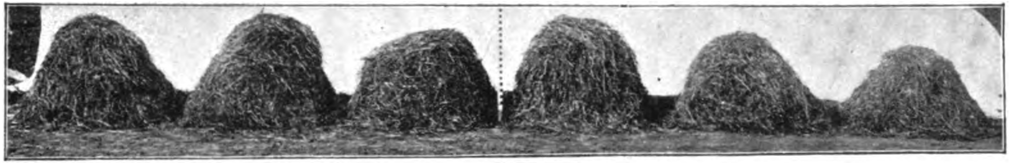


Fig. 3.—Millet.
Potassium and Sodium Chlorids. ***Limed.***

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¾	¼

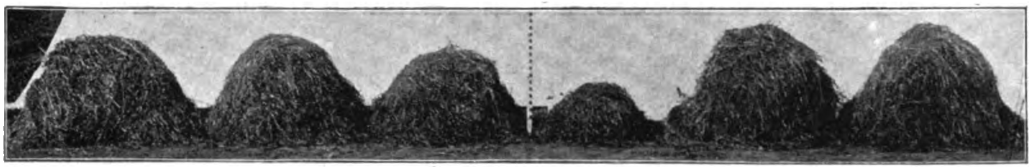


Fig. 4.—Millet.
Potassium and Sodium Chlorids. ***Limed.***

Potash ration	¾	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

Fig. 5—Millet.
Potassium and Sodium Carbonates. *Unlimed.*

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¾	¼

Fig. 6.—Millet.
Potassium and Sodium Carbonates. *Unlimed.*

Potash ration	¾	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

Fig. 7.—Millet.
Potassium and Sodium Carbonates. *Limed.*

Potash ration	1	1	1	1	¾	¼
Soda ration	¾	½	¼	0	¾	¼

Fig. 8.—Millet.
Potassium and Sodium Carbonates. *Limed.*

Potash ration	¾	½	¼	0	1	½
Soda ration	1	1	1	1	1	½

TABLE I.

Table showing the yields, in pounds, of oats and millet, where compounds of potassium and sodium were used separately and combined in various proportions.

	SODIUM CHLORID AND POTASSIUM CHLORID.				SODIUM CARBONATE AND POTASSIUM CARBONATE.			
	Unlimed.		Limed.		Unlimed.		Limed.	
	1 ration soda. 0 ration potash.	1 ration potash. 0 ration soda.	1 ration soda. 0 ration potash.	1 ration potash. 0 ration soda.	1 ration soda. 0 ration potash.	1 ration potash. 0 ration soda.	1 ration soda. 0 ration potash.	1 ration potash. 0 ration soda.
PLOT No.	4	10	16	22	28	34	40	46
Oats*	295.0	360.0	260.0	360.0	210.0	305.0	235.0	300.0
Millet†	42.5	137.5	27.5	155.0	25.0	147.5	30.0	152.5

	SODIUM CHLORID AND POTASSIUM CHLORID.				SODIUM CARBONATE AND POTASSIUM CARBONATE.			
	Unlimed.		Limed.		Unlimed.		Limed.	
	1 ration soda. 1 ration potash.	¾ ration potash. ¾ ration soda.	1 ration soda. 1 ration potash.	¾ ration potash. ¾ ration soda.	1 ration soda. 1 ration potash.	¾ ration potash. ¾ ration soda.	1 ration soda. 1 ration potash.	¾ ration potash. ¾ ration soda.
PLOT No.	5	11	17	23	29	35	41	47
Oats*	360.0	325.0	370.0	340.0	275.0	285.0	330.0	300.0
Millet†	120.0	110.0	185.0	130.0	135.0	140.0	195.0	152.5

	SODIUM CHLORID AND POTASSIUM CHLORID.				SODIUM CARBONATE AND POTASSIUM CARBONATE.			
	Unlimed.		Limed.		Unlimed.		Limed.	
	½ ration soda. ½ ration potash.	¼ ration potash. ¼ ration soda.	½ ration soda. ½ ration potash.	¼ ration potash. ¼ ration soda.	½ ration soda. ½ ration potash.	¼ ration potash. ¼ ration soda.	½ ration soda. ½ ration potash.	¼ ration potash. ¼ ration soda.
PLOT No.	6	12	18	24	30	36	42	48
Oats*	330.0	305.0	355.0	300.0	280.0	235.0	285.0	270.0
Millet†	97.5	97.5	145.0	92.5	105.0	82.5	152.5	95.0

* Oats as first crop, cut and weighed green.

† Millet as second crop, cut and weighed green.

Table II.

Table showing the yields, in pounds, of the oats and millet, where compounds of potassium and sodium were used separately and combined in various proportions.

	Sodium Chlorid and Potassium Chlorid.				Sodium Carbonate and Potassium Carbonate.			
	Unlimed.		Limed.		Unlimed.		Limed.	
	1 ration soda. ¾ ration potash.	1 ration potash. ¾ ration soda.	1 ration soda. ¾ ration potash.	1 ration potash. ¾ ration soda.	1 ration soda. ¾ ration potash.	1 ration potash. ¾ ration soda.	1 ration soda. ¾ ration potash.	1 ration potash. ¾ ration soda.
Plot No	1	7	13	19	25	31	37	43
Oats*	345.0	330.0	360.0	350.0	270.0	280.0	305.0	315.0
Millet†	130.0	125.0	195.0	185.0	135.0	145.0	210.0	225.0

	Sodium Cholrid and Potassium Chlorid.				Sodium Carbonate and Potassium Carbonate.			
	Unlimed.		Limed.		Unlimed.		Limed.	
	1 ration soda. ½ ration potash.	1 ration potash. ½ ration soda.	1 ration soda. ½ ration potash.	1 ration potash. ½ ration soda.	1 ration soda. ½ ration potash.	1 ration potash. ½ ration soda.	1 ration soda. ½ ration potash.	1 ration potash. ½ ration soda.
Plot No	2	8	14	20	26	32	38	44
Oats*	350.0	360.0	365.0	355.0	280.0	300.0	290.0	315.0
Millet†	112.5	145.0	150.0	147.5	105.0	135.0	145.0	187.5

	Sodium Chlorid and Potassium Chlorid.				Sodium Carbonate and Potassium Carbonate.			
	Unlimed.		Limed.		Unlimed.		Limed.	
	1 ration soda. ¼ ration potash.	1 ration potash. ¼ ration soda.	1 ration soda. ¼ ration potash.	1 ration potash. ¼ ration soda.	1 ration soda. ¼ ration potash.	1 ration potash. ¼ ration soda.	1 ration soda. ¼ ration potash.	1 ration potash. ¼ ration soda.
Plot No	3	9	15	21	27	33	39	45
Oats*	320.0	335.0	335.0	365.0	260.0	305.0	300.0	340.0
Millet†	110.0	140.0	110.0	140.0	105.0	160.0	125.0	200.0

*Oats as first crop, cut and weighed green.

†Millet as second crop, cut and weighed green.

Many points of interest are brought out in the foregoing tables. It will be seen that in each case the yield of oats from a full ration of potassium was much larger than from a full ration of sodium. The same was true even to a greater extent of the millet, which succeeded the oat crop. In 1896 a greater difference was also observed in the second than in the first crop. This difference in the results exhibited by the first and second crops may possibly be attributed to a greater power of oats than of millet to extract potash from the soil. It may also be true that during the winter months a considerable amount of potash was rendered assimilable upon the sodium plot by the action of atmospheric agencies upon the soil, in consequence of which a larger supply was at the disposal of the first than of the second crop. The fact that oats can more readily extract their potash supply from the soil than other cereals lends much support to the idea that they might even exceed millet in this particular.

Letting 10 represent the yield of oats from each of the full ration sodium plots in 1897, the corresponding yields from the four full ration potassium plots are as follows: 12, 14, 15 and 13. Applying the same method of comparison to both crops, in the years 1896 and 1897, we obtain the following figures:

YEAR OF 1896.		YEAR OF 1897.	
Oats (first crop).	Golden Millet (second crop).	Oats (first crop).	Golden Millet (second crop).
9	15	12	32
11	46	14	56
12	32	15	59
10	31	13	51

It will be seen from the above that the yield of oats in 1896 was but 9 on one of the full ration potassium plots, as compared with ten on the full ration sodium plot. In one other instance the difference was so slight that it does not appear unless 100 is taken as the standard of comparison instead of 10. In all other cases the yield from the full ration sodium plot falls far behind that

from the plots where a full ration of potassium was applied. Comparing the oat crop of 1897 with that for 1896, it is seen at once that the inferiority of the sodium plots had become much more manifest in 1897 than it was in 1896. This is attributed to the gradual depletion of the stock of assimilable potash in the soil of the soda plots. Comparing the first and second crops in 1896, it is at once seen that the inferiority of the full ration sodium plots, as compared with the corresponding potassium plots, was much greater with the second crop than with the first. The relative difference between the two was even more striking in 1897 than in 1896.

By an inspection of the results where sodium compounds in increasing quantities are added to a full potassium ration, it is impossible to conclude with certainty that the sodium ration has been of any particular value. On the other hand, where potassium compounds have been added in increasing quantities to a full sodium ration, a marked and fairly uniform increase in yield is noticeable in the case of the quarter and half rations of potassium.

In some instances the half ration of potassium seemed to have been nearly enough, since no further increase was effected by the addition of an extra quarter ration.

Having seen that the addition of one-quarter, one-half and three-quarter rations of potassium to a full sodium ration was highly beneficial, and that such was not the case where one-quarter, one-half and three-quarter rations of sodium were added to a constant potassium ration, it might be argued that sodium compounds were of no use whatever. It may be properly objected to this, however, that the sodium compounds would not be expected to exert any appreciable effect, if at all, unless they were used in connection with much smaller amounts of potassium than would be furnished by the full ration of that element. It is of special interest, therefore, to make a series of comparisons which throw light upon this particular point. Four comparisons with the first crop (oats), and four with the second crop (millet) are permissible, namely, where carbonates of sodium and potassium were

tried upon limed and unlimed land, and also where chlorids of sodium and potassium were similarly tried.

Comparing first the results obtained by the use of a three-quarter ration of potassium and a three-quarter ration of sodium with those obtained by employing a three-quarter ration of potassium and a *full* ration of sodium, it is seen that, in the case of the first crop, greater returns were obtained in three instances, and a lesser return in one instance, from the full than from the three-quarters ration of sodium. In connection with the second crop it was also true that in three instances greater returns were secured from the full than from the three-quarter ration of sodium.

Comparing now the results from a half ration each of potassium and of sodium with those obtained with a half ration of potassium and a *full* ration of sodium, it is seen that, in the case of the first crop, the yields were identical in one instance, and in the three other cases they were greater where the full ration of sodium was employed. With the second crop they were also identical in one instance but greater in the three others where the full soda ration was used.

Comparing finally the results from a quarter ration of potassium and a quarter ration of sodium with those obtained with a quarter ration of potassium and a *full* ration of sodium, it will be seen that the yields, in the case of both the first and second crop, were much greater in every instance where the full ration of sodium was employed.

These data point very strongly to a beneficial action of the sodium where but a limited supply of assimilable potash is at hand. Whether the benefit from sodium in this instance is attributable to its having liberated potash within the soil, or to its having acted as a direct plant food, can only be determined by analyses of the crops. Samples were taken from many of the plots for this purpose, and the results will be reported upon later, when the material will all have been analyzed.

It has already been shown by Atterberg and others, as stated in

previous discussions of this experiment, that soda can be substituted for potash. This does not, so far as shown, result to any considerable extent unless the supply of potash is limited. By thus limiting the supply of potash it remains to be seen if the crop will not be so much reduced that it would not prove an economical practice, notwithstanding the fact that it has been forced into using some soda. This is a point which does not, thus far, seem to have attracted the attention of those who have been investigating the question of the substitution of potassium by sodium. It is hoped that by the end of the season of 1898 enough data will have been procured to render possible some conclusions on this point. Even if it is found that a substitution of soda for a part of the potash supply is not an economical practice with certain plants, it may, nevertheless, be true of others. This seems probable in view of data secured in other experiments at this Station, and in consideration of the high percentage of soda contained in certain agricultural plants. All of these points, it is hoped, will be brought out by a continuation of these observations.

ON THE MANURIAL ACTION OF NITRATE OF POTASH AS COMPARED WITH LIKE QUANTITIES OF NITROGEN AND POTASH IN FORM OF NITRATE OF SODA AND MURIATE OF POTASH.

This experiment was begun in 1895,[1] when observations were obtained with red table beets, and sugar beets. In 1896[2] the crops were barley and clover.

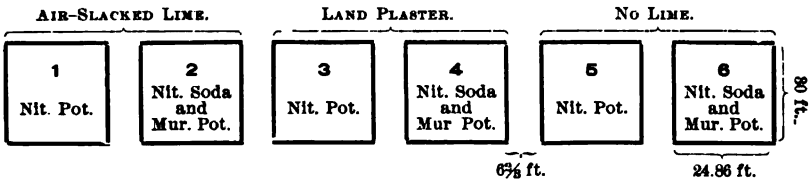
Each year of the experiment like quantities of dissolved boneblack and sulfate of magnesia (Epsom salts) were applied to all of the plots. The total quantity of nitrogen and potash used on each plot has been maintained the same throughout, though supplied in different forms. In 1895 one pair of plots received air-slacked

[1] Eighth An. Rp't R. I. Agr'l Exp't Sta. (1895), pp. 226-231.

[2] Ninth An. Rp't R. I. Agr'l Exp't Sta. (1896), pp. 237-241.

lime, another pair an equivalent amount of lime in the form of land plaster (gypsum), and the third pair no lime. Since 1895 no more lime has been applied. In 1897 dissolved boneblack was applied at the rate of 800 pounds, and sulfate of magnesia at the rate of 400 pounds per acre. On plots 1, 3 and 5, nitrate of potash was applied at the rate of 426.9 pounds per acre (7.3 pounds per plot), and on plots 2, 4 and 6, nitrate of soda was applied at the rate of 375.4 pounds per acre (6.42 pounds per plot), and also muriate of potash at the rate of 400 pounds per acre (6.7 pounds per plot).

The following diagram shows the size and arrangement of the plots:



In 1895 these plots were each divided into two equal parts, table beets having been grown upon one side and sugar beets upon the other.

In 1896 one-half of each plot was seeded to clover, while upon the other barley and Timothy were sown. This seeding with Timothy proved a failure, and, consequently, after the removal of the barley it was reseeded.

In 1897 the results with clover and Timothy were recorded, the data being given in the subjoined table.

Table Showing the Results Secured with Nitrate of Potash in comparison with like quantities of Nitrogen and Potash in the form of Nitrate of Soda and Muriate of Potash. (The weights of Crops represent Pounds per Plot, and weights of Fertilizers, Pounds per Acre.)

NAME OF CROP.	5,000 pounds of Air-Slacked Lime in 1895.*		9,805 pounds of Land Plaster in 1895.*		No Lime.	
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	Dis. Boneblack, 800 lbs. Sul. of Magnesia, 400 lbs. Nit. of Potash, 426.9 lbs.	Dis. Boneblack, 800 lbs. Sul. of Magnesia, 400 lbs. Nit. of Soda, 375.4 lbs. Mur. of Potash, 400 lbs.	Dis. Boneblack, 800 lbs. Sul. of Magnesia, 400 lbs. Nit. of Potash, 426.9 lbs.	Dis. Boneblack, 800 lbs. Sul. of Magnesia, 400 lbs. Nit. of Soda, 375.4 lbs. Mur. of Potash, 400 lbs.	Dis. Boneblack, 800 lbs. Sul. of Magnesia, 400 lbs. Nit. of Potash, 426.9 lbs.	Dis. Boneblack, 800 lbs. Sul. of Magnesia, 400 lbs. Nit. of Soda, 375.4 lbs. Mur. of potash, 400 lbs.
Clover, first crop (weighed green).................	131.5	101.3	147.0	142.4	104.3	82.0
Clover, second crop (weighed green)....................	82.0	55.0	110.0	115.0	95.0	70.0
Clover, both crops† (weighed green)	*213.5*	*156.3*	*257.0*	*257.4*	*199.3*	*152.0*
Timothy, first crop (weighed green)..	111.0	121.0	96.0	85.0	116 0	101.0
Timothy, sec'd crop (weighed green)	11.5	12.3	5.0	20.0	27.0	12.0
Timothy, both crops (weighed green)	*122.5*	*133.3*	*101.0*	*105.0*	*143.0*	*113.0*

* The amount of air-slacked lime and land plaster were such as to furnish the same amounts of lime. (Calcium oxid.)

† The clover on plots 1 and 2 was more mature when harvested than that on the other plots, and consequently weighed less than it would if it had been as immature as that on the other plots.

It should be stated that when the clover seed was sown the surface soil on the air-slacked lime plots was not as moist as on the other, and it is supposed that considerable quantities of seed were blown from those plots by a high wind which prevailed soon after. It would be probable under such circumstances that the two plots would not suffer equally. On account of this injury, an imperfect

stand of clover was secured on the limed plots, though such as grew was excellent.

The results from one season cannot be expected to be very conclusive, and, in fact, a review of the experiment for 1895, 1896, and 1897, shows such conflicting data that it is absolutely impossible at this time to conclude definitely from them as to whether nitrate of potash is or is not preferable to muriate of potash and nitrate of soda. The data are, therefore, simply published here as a matter of record.

SUMMARY OF THE GENERAL RESULT OF FOUR YEARS' EXPERIMENTS.

It may be stated at this time that, with each succeeding year, soda, when used without potash, has steadily deteriorated in its action when compared with the results from plots manured with potash, but without soda.

Where soda has been added in increasing quantities to a full potash ration, little or no benefit from its use has been apparent. On the other hand, the addition of increasing quantities of potash to a full soda ration, has, especially in the last two years, been attended with most marked gains.

In the instances where potash and soda have both been employed in varying amounts, marked evidence of benefit from soda is noticeable in the results for 1897, particularly where the potash ration was reduced to one-fourth of the maximum amount.

There seems to be some doubt if it would prove an economical practice to reduce the supply of potash sufficiently to gain the greatest benefit from the soda, for, by so doing, the total crop seems to be seriously reduced. It may be possible that certain plants may be able to make use of soda without the danger just men-mentioned. This point can only be determined by further experimentation.

It is not known at present, and cannot be until the analytical

data are all available, whether the soda has probably acted as a direct plant food, or indirectly by virtue of its having liberated some potash or other manurial ingredients. It is hoped that something in this connection will be ready for publication in the near future.

OBSERVATIONS REGARDING THE RELATIVE ASSIMILABILITY OF VARIOUS FORMS OF NITROGEN UPON AN ACID SOIL, LIMED AND UNLIMED.

H. J. WHEELER, B. L. HARTWELL, G. E. ADAMS.

This experiment was conducted in galvanized iron pots 18 inches in diameter and 26 inches deep. The pots were set into the soil so that their tops projected about two inches. Under them were placed drain tiles to carry away surplus water. The bottoms of the pots sloped towards the center, at which was a small opening to insure drainage. A few small stones were first placed in the bottom of each pot, and upon them 154 pounds of sub-soil, taken from beside the so-called "co-operative acre," or twentieth acre experimental plots, described elsewhere.[1] One hundred pounds of surface soil from plot 00, of the above mentioned experimental field, were then added to each pot.

The pots were set and the experiment begun in the spring of 1893. From 1893 until 1897 inclusive, like quantities of dissolved boneblack, muriate of potash and nitrogen in the several forms have been added annually to each pot. The dried blood, used during the entire time, was from the same lot, and the quantities of the other nitrogenous materials were modified from year to year, according to their varying composition, to conform thereto. The dried blood was of good quality and contained 12.45 per cent. of nitrogen. In the case of each form of nitrogen, two

[1] Third An. Rpt. R. I. Ag'l. Expt. Station for 1890, p. 89.

pots were treated with air-slacked lime at the rate of 147.2 grams per pot, or 4 tons per acre, while the other two received no lime whatever. No lime has been applied to any of the pots since the first year of the experiment.

In 1893 dissolved boneblack was employed at the rate of 1,200 pounds per acre, or 22.0746 grams per pot, and muriate of potash at the rate of 400 pounds per acre, or 7.3582 grams per pot. The dried blood has been employed annually at the rate of 21.2772 grams per pot, a quantity equivalent in nitrogen to 720 pounds per acre of sulfate of ammonia containing 20 per cent of nitrogen.

In pots 2, 9, 3, and 10 "Pennsylvania tankage," containing 8.9 per cent. of nitrogen, was employed in 1893 and 1894, but in each of the succeeding years finely ground leather containing 7.06 per cent. of nitrogen, has been substituted for it. In 1895, and in each subsequent year of the experiment, the quantities of muriate of potash and dissolved boneblack employed per pot were increased to 10 and 25 grams respectively.

Maize was raised in the pots in 1893, but, owing to the unavoidable individuality of the plants, and to the limited number which could be grown in each pot, the results were far from satisfactory.[1]

The most interesting feature of this experiment, at the outstart, was the great difference in the effectiveness of the organic nitrogen of the dried blood, and of the "Pennsylvania" tankage, when not employed in connection with lime. This was attributed to the fact that the dried blood reacted alkaline and the "Pennsylvania" tankage, acid. This conclusion seemed fully justifiable in view of the experience of A. Müntz, and A. C. Girard,[2] in connection with nitrification[3] experiments with an acid (sour) soil from Brittany.

Had the soil employed in our experiment been alkaline at the

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[1] See Sixth An. Rpt. R. I. Ag'l Exp't. Station (1893), pp. 267-270.

[2] Annales Agron. 17 (1891), p. 299.

[3] By nitrification is meant the process or processes by which ammonia is changed to nitric acid, a form readily assimilable by plants.

outstart it would have tended to neutralize the acidity of the tankage to such an extent as to permit its more ready nitrification.

In 1894 oats were substituted for maize, but, owing to injury from exposure to an unusual storm, the data obtained were rendered less satisfactory than otherwise.

Results with Oats in 1894.

FORMS OF NITROGEN EMPLOYED.	Pot Number.	Limed. Grams per pot.*	Unlimed. Grams per pot.*
Without Nitrogen	20	......	17.2
	27	......	19.4
	23	55.8	....
	24	60.2	....
Nitrate of Soda	6	......	59.4
	13	......	69.9
	7	78.6	....
	14	63.9	....
Sulfate of Ammonia	18	......	7.1
	25	......	14.0
	19	72.9	....
	26	83.1	....
Dried Blood	4	......	58.9
	11	......	50.3
	5	67.9	....
	12	68.1	....
"*Pennsylvania*" *tankage*	2	......	45.7
	9	......	47.3
	8	73.1	....
	10	76.5	....

Comparing the unlimed sulfate of ammonia pots (18 and 25) with the unlimed pots where no nitrogen was used (20 and 27), it will be seen that evidence is afforded of positive injurious action of the sulfate of ammonia, which accords fully with many other observations made at this Station, in the field. Comparing the

*The oats were cut when just past the "milk," and the weights are those of material dried at 100° C.

unlimed "Pennsylvania" tankage pots (2 and 9), with the unlimed ones which received no nitrogen (20 and 27), it becomes evident that the nitrogen of the tankage was probably assimilated to a considerable extent, but in a less degree than that of the dried blood or nitrate of soda of the unlimed pots.

In this respect the observation agrees with that of 1893, with maize. After having noted this point, it is of particular interest to observe that where lime was used the "Pennsylvania" tankage gave results comparing well with the other forms of nitrogen. The yields in the case of the limed pots which received no nitrogen, are not equal to those limed pots where nitrogen was applied, showing conclusively that the nitrogen had been utilized. It is seen that while sulfate of ammonia acted like a poison upon unlimed soil, it was a useful manure where sufficient lime was at hand.

It is not fair to conclude that the difference between the limed and unlimed pots without nitrogen, was due solely to nitrogen which had been rendered assimilable, for some difference is observable between the limed and unlimed nitrate of soda pots which was very likely due in part to other causes, which, doubtless, operated also in the other cases. It is probable from many other observations in the field and in pots, that the action of the acidity of the soil upon the growth of the oats, as well as a physical or manurial effect of the lime, may each have exerted a measurable influence. The results show plainly that the acidity or absence of carbonate of lime or other bases in soils, influences in a marked degree the results obtainable with various forms of nitrogen.

RESULTS IN 1895.

The following table shows the results secured with spring rye in 1895. It will be noticed that leather waste was substituted in 1895 for the "Pennsylvania" tankage previously employed, though the total amount of nitrogen, per pot, remained the same.

Results with Spring Rye in 1895.

FORMS OF NITROGEN EMPLOYED.	Pot Number.	Limed. Grams per pot.*	Unlimed. Grams per pot.*
Without Nitrogen	20	......	4.2
	27	....	8.8
	23	56.7	....
	24	44.6	....
Nitrate of Soda	6	....	22.7
	13	....	24.5
	7	118.7	....
	14	93.6	....
Sulfate of Ammonia	18	....	0.6
	25	....	1.0
	19	108.4	....
	26	97.5	......
Dried Blood	4	....	1.0
	11	....	1.7
	5	117.6	....
	12	100.5	......
Ground Leather	2	....	3.9
	9	....	8.9
	3	64.9	......
	10	76.3	....

The results in the preceding table obtained from parallel pots are not, in all cases, as uniform as could be wished. This was due chiefly to slight injury to the immature grain caused by an unexpected attack by sparrows. The results are, nevertheless, sufficiently valuable and striking to justify their publication.

As in the experiment with oats, in 1894, the yield was less with, than without sulfate of ammonia, in the unlimed series, showing its unmistakable poisonous action where a great degree of soil acidity existed. The superiority of nitrate of soda as a form of nitrogen for acid soils is again strikingly manifested.

In the limed series it is evident that the nitrogen of the leather,

* The rye was cut when past the "milk" and was dried for several weeks in a warm room under like conditions before weighing,

or, possibly, the residual nitrogen of the "Pennsylvania" tankage, used in the two preceding years, had exerted a beneficial effect, though it was manifestly inferior, in its crop producing power, to nitrate of soda, sulfate of ammonia and dried blood. Owing to the inequalities in the results from parallel pots no conclusion as to the relative merits of the three other forms of nitrogen, in the limed series, can be drawn.

RESULTS IN 1896.

The experiment in 1896 was continued as in 1895, except that barley was grown instead of rye.

For the reason that plants of the same kind, weighing exactly alike, may contain unlike amounts of nitrogen, and since the actual amount of nitrogen in plants is dependent, within certain limits, upon the quantity of that element present in assimilable form within the soil, the quantities of nitrogen removed from the soil by the crop have, in most cases, been determined. By this means much more reliable information is furnished as to the relative assimilability of the several forms of nitrogenous manures.

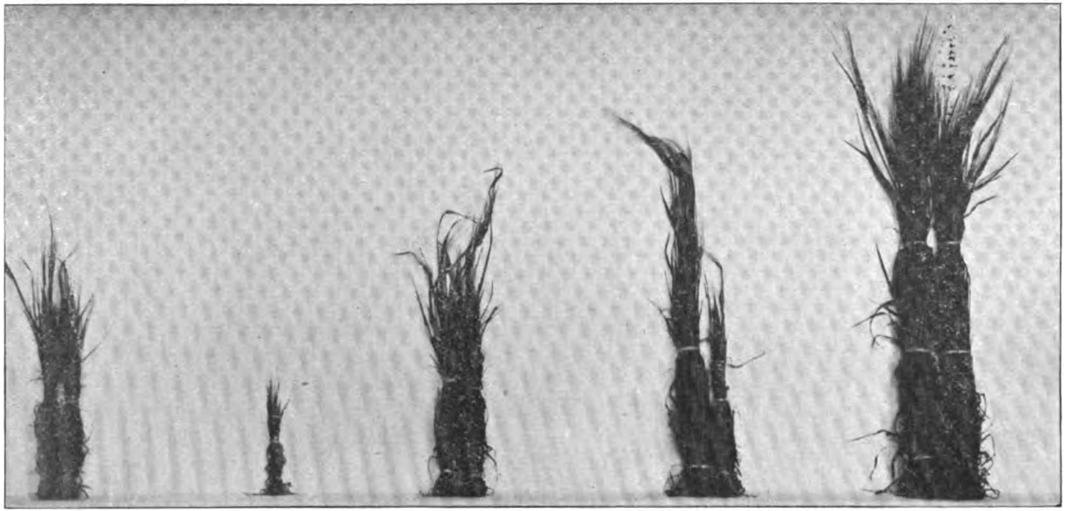

FIG. 1. BARLEY (*Unlimed*).

No nitrogen. Sul. of Am. Leather. Blood. Nit. of soda.

All manured alike with potash and phosphoric acid. Like *quantities* of nitrogen were applied in each case.

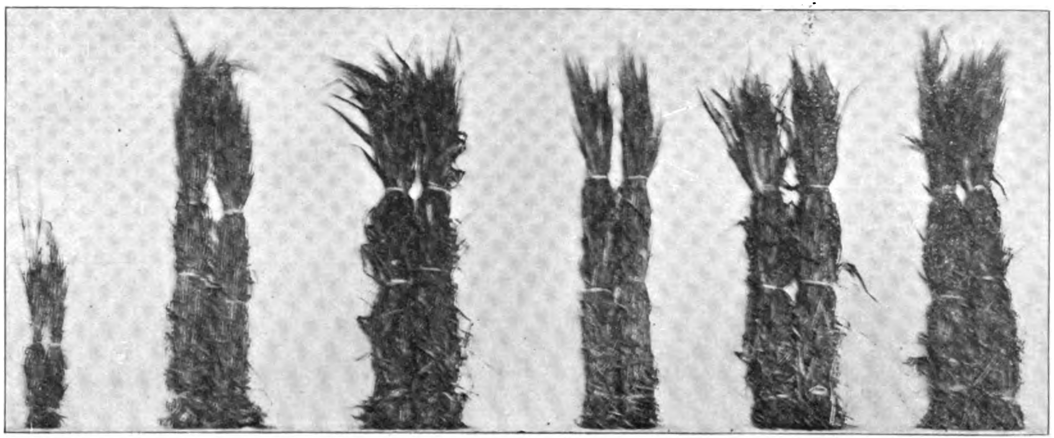

FIG. 2. BARLEY (*Limed, excepting the first lot at the left.*)

No nitrogen. No nitrogen. Sul. of Am. Leather. Blood. Nit. of soda.

All manured alike with potash and phosphoric acid. The quantities of nitrogen were identical in each instance and the same as in Fig. 1.

Table showing the Results with Barley in 1896. (See illustrations, Figs. 1 and 2.)

Forms of Nitrogen Employed.	Pot Number.	Limed.			Unlimed.		
		Grams of barley hay per pot.*	Per cent. of nitrogen in the crop (fully dry).	Grams of nitrogen obtained from the soil by the crop.	Grams of barley hay per pot.*	Per cent. of nitrogen in the crop.	Grams of nitrogen obtained from the soil by the crop.
Without Nitrogen	20	......	......	....	9.61	1.75	0.168
	27	......	...	......	8.18	1.14	0.098
	23	58.67	1.14	0.791	.....	.....	.....
	24	69.26	1.00	0.693	......	....	.....
Nitrate of Soda	6	......	......	......	51.07	2.29	1.170
	18	......	......	...	51.12	2.43	1.242
	7	100.32	2.17	2.177	.....	......	.....
	14	103.56	2.07	2.144	......	......	.....
Sulfate of Ammonia	18	......	....	.....	‡	‡	‡
	25	......	......		2.46	†	†
	19	102.48	2.00	2.050	......	.....	......
	26	98.78	1.66	1.640	.. ..	......	...
Dried Blood	4	......	......	......	21.26	2.32	0.493
	11	......	......	.....	32.85	2.27	0.746
	5	118.21	1.73	2.045	......	......	......
	12	120.52	1.66	2.000	......	......	......
Ground Leather	2	......	.....	......	11.20	1.89	0.212
	9	......	......	......	11.71	2.06	0.241
	3	73.90	1.23	0.909	...	......	......
	10	79.14	1.22	0.966	....	.....	.....

The results embodied in the above table are quite uniform in character so far as concerns parallel pots, and they bring out several points of interest. As in other years nitrate of soda showed its marked superiority to the other forms of nitrogen upon an unlimed acid soil, and sulfate of ammonia exerted an injurious instead of a beneficial action.

In the unlimed series the weight of the crop produced, and also the amount of nitrogen removed from the soil, in the two cases

*Cut when in the "milk." The weights given are those of the material dried at 100° C.

† Nitrogen not determined, owing to the small amount of substance.

‡ This pot received caustic magnesia in 1896, and the results are to be published in another connection.

18

where leather was employed (pots 3 and 10), indicate, when compared with the results without nitrogen (pots 20 and 27), that the nitrogen had been utilized by the plants to a slight extent. The dried blood was assimilable to a much greater extent than the leather, as indicated by the greater weights of the crops and by the quantities of nitrogen taken up by the crop (pots 4 and 11).

In the limed series it will be seen that, so far as concerns the weight of dry matter in the crop, dried blood proved superior to either sulfate of ammonia or nitrate of soda, yet the plants receiving nitrate of soda actually removed the largest amount of nitrogen from the soil. In this instance the weight of the crop fails to indicate properly the relative assimilability of the nitrogen of the blood and of the nitrate of soda.

It is of interest to note that the greatest weight of dry matter was not produced by the plants which assimilated the largest quantity of nitrogen. It may be that this was due to the fact that, aside from nitrogen, dried blood contains very small amounts of potash, phosphoric acid and other ingredients which may have been beneficial to the plant and enabled it to make a better use of the nitrogen at its disposal, or, that the plants on the nitrate of soda plots were surfeited with nitrates to such an extent as to possibly interfere in some way with the proper elaboration of their food. The generous application of dissolved boneblack and muriate of potash, which was made in all the cases, would, however, tend to throw some doubt on the former supposition. The results indicate, particularly in consideration of the amounts of nitrogen taken up by the crop, that the sulfate of ammonia was not as assimilable as the nitrate of soda, and, indeed, Wagner and Dorsch[1] set their relative values as 91 to 100, when the soil conditions are favorable to nitrification.[2]

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[1] Die Stickstoffdüngung der landw. Kulturpflanzen, Berlin, 1892, p. 197.

[2] In the case of beets and certain other plants sulfate of ammonia does not compare as favorably with the nitrate of soda, but this appears to be due to a favorable action of the soda or to differences in the reaction of the soil as concerns acidity or alkalinity induced by the residual soda on the one hand and by the residual sulfuric acid on the other.

Even in the limed series, where the conditions for nitrification were as favorable as possible, the inferiority of the leather was extremely marked as shown by the small yield and by the limited quantity of nitrogen which was assimilated.

RESULTS IN 1897.

Barley was again employed in this experiment in 1897. As in 1896, the total amount of dry matter, the percentage of nitrogen in the dry matter, and the total amount of nitrogen removed by the crop, have been determined. The data obtained are embodied in the subjoined table.

The yields were smaller in 1897 than in the previous year, largely on account of unequal germination of the seed and the fact that considerable thinning was necessary to secure a like number of plants in each pot.

Table showing the Results with Barley in 1897.

Forms of Nitrogen Employed.	Pot Number	Limed. Grams of barley hay per pot.*	Limed. Per cent. of nitrogen in the crop (fully dried).	Limed. Grams of nitrogen obtained from the soil by the crop.	Unlimed. Grams of barley hay per pot.*	Unlimed. Per cent. of nitrogen in the crop (fully dried).	Unlimed. Grams of nitrogen obtained from the soil by the crop.
Without Nitrogen	20	......	....	.....	4.69	‡	‡
	27	......	....	......	2.40	‡	‡
	23	32.79	†	†	......	......	.....
	24	27.19	†	†	......	......	....
Nitrate of Soda	6	......	....	......	42.33	2.01	0.851
	13	......	....	..	28.24	2.02	0.570
	7	80.37	2.02	1.623	.....	......	......
	14	75.86	1.91	1.449	......	......	......
Sulfate of Ammonia	18	......	....	....	¶	¶	¶
	25	..	.....	.....	1.23	‡	‡
	19	79.96	1.76	1.407	......	......	......
	26	61.95	1.89	1.171	.....	....	....
Dried Blood	4	......	.....	......	12.31	1.95	0.240
	11	..	..	.....	**	**	**
	5	85.37	1.60	1.366	.....	......	......
	12	87.26	1.67	1.457	....	......	.....
Ground Leather	2	......	.....	......	8.06	1.67	0.135
	9	......	.....	.....	9.74	1.60	0.156
	3	30.45	1.58	0.466	......	.....	.....
	10	40.96	1.26	0.516	......	......	......

It will be seen from the foregoing table that in the unlimed series the amount of crop from the dried blood pot (No. 4) was greater than where leather was applied (pots 2 and 9), as was also the total quantity of nitrogen removed by the crop. Nitrate of soda, as a source of nitrogen on an acid soil, has again shown its marked superiority, the total product of barley hay, and the amount of nitrogen removed, being far greater in the case of those pots than

* Cut when in the "milk." The weights given are those of the material dried at 100° C.

† Not determined.

¶ This pot received caustic magnesia in 1896 and 1897, and the results are to be published in another connection.

‡ Nitrogen not determined, owing to the small amount of substance.

** This pot became water-logged, and was omitted from the experiment in 1897.

in any of the others. Sulfate of ammonia, in the unlimed series, has exhibited the same poisonous action as in former years.

In the limed series the variations in the results in the parallel pots are too great to admit of close comparisons as to the relative effectiveness of nitrate of soda, sulfate of ammonia, and dried blood. The prominent feature of the results in this series is the striking inefficiency of leather as compared with the other forms of nitrogen.

This experiment, like those of previous years, shows the striking inefficiency on an acid soil of even the best forms of nitrogen, which must first be nitrified before becoming fully assimilable.

Deducting the amount of nitrogen found in the crop from the pots without nitrogen, from that in the pots where nitrogen was added, and then letting 100 represent the average amount of nitrogen taken from the soil by the plants in the nitrate of soda pots, we obtain the following values for the nitrogen which the plants were able to obtain from the other forms of nitrogen employed. In the limed and unlimed series the appropriate blank belonging to each was of course deducted.

FORMS OF NITROGEN.	Pot Number.	Relative amounts of nitrogen obtained by the crop, like quantities having been applied in each case. LIMED. Single Pots.	LIMED. Average.	Pot Number.	UNLIMED. Single Pots.	UNLIMED. Average.
Nitrate of Soda	23, 24	......	*100*	20, 27	......	*100*
Sulfate of Ammonia	19	92 2	.....	....	......	......
	26	63.2*	*92.2*	......	....	......
Dried Blood	5	91.9	.....	4	33.7	......
	12	88.7	*90.3*	11	57.3	*45.5*
Ground Steamed Leather	3	11.8	.....	2	0.8	......
	10	15.8	*13.8*	9	1.0	*0.9*

* Omitted from average since there was so much difference in the two pots and because it failed to accord with results obtained by others.

It will be seen from the foregoing that where the conditions for nitrification are rendered favorable by the employment of lime, the assimilability of the sulfate of ammonia and of dried blood was about nine-tenths as great as that of the nitrate of soda which, being fully assimilable, is taken as a standard. The ground steamed leather, however, made a poor showing in comparison, the assimilability being represented by 13.8 as compared with 90.3 for dried blood.

In the unlimed series, where the conditions for the change of the nitrogen to nitrates were unfavorable, the assimilability of the dried blood dropped about one-half, and that of the leather to 0.9, or practically nothing. The sulfate of ammonia proved in this case positively injurious, and the growth was in consequence too small to make it of any use to attempt to determine the percentage of nitrogen.

In this experiment the amount of nitrogen assimilated by the plants stands in no definite relation to the quantity of dry matter produced. Two possible causes for this have been already mentioned, the most probable of which seemed to be that the plants had been surfeited with nitrates at certain stages of their growth, and had, in consequence, been unable to make the best possible use of it. In view of several experiments on record which indicate that plants may feed to a certain extent directly on soluble organic matter, it is possible that some advantage may be derived, in certain instances and under certain conditions, by the assimilation of food already in a partially organized condition.

SUMMARY.

On a very acid (sour) soil sulfate of ammonia has worked like a poison instead of as an effective fertilizer.

Where air-slacked lime was applied with sulfate of ammonia, the nitrogen proved nearly as valuable as like quantities in form of nitrate of soda.

Dried blood, on the acid soil, yielded some nitrogen to the plants and proved its marked superiority to the leather.

When used in connection with lime the nitrogen of the dried blood became nearly as effective as like amounts in the form of nitrate of soda, while nitrogen in the form of leather was very ineffective even when, by liming, the conditions for its nitrification were made as favorable as possible. That the conditions for nitrification were favorable in the limed pots, is shown by the fact that the nitrogen of the sulfate of ammonia and dried blood became almost as effective as nitrate of soda.

These results bring out plainly the fact that upon an acid soil, where nitrification progresses but slowly, much of the money invested in the best forms of organic nitrogen, such as blood, meat and fish, is practically wasted; and since these forms make up the major part of the nitrogen of most of the commercial fertilizers sold in the State, the importance of testing soils for their acidity and supplying lime where needed, cannot be too strongly insisted upon.

ON THE USE OF FLOWERS OF SULFUR AND SULFATE OF AMMONIA AS PREVENTIVES OF THE POTATO SCAB IN CONTAMINATED SOILS.

H. J. WHEELER AND G. E. ADAMS.

In view of Halsted's[1] favorable recommendation of flowers of sulfur as a preventive of the potato scab, particularly in the case of soils already badly contaminated, a few tests of its efficiency were made in 1896.[2] As a result of those trials it was stated that the *sulfur when mixed thoroughly* (at the rate of 600 pounds per acre) *with the upper seven to eight inches of a badly contaminated soil, favorable to the disease, though checking the scab somewhat, was practically useless.* In view of the fact that but a limited number of observations were made in 1896, it was deemed desirable to still further study the question in 1897. For this purpose, the pots and soils employed previously in studying the effect of various calcium compounds, stable manure, etc., upon the scab, were used.

Experiment A.

The previous treatment of the soils and pots involved in this experiment has been described in full elsewhere.[3] Barn-yard manure was employed in the pots in 1894, 1895, and 1896, at the

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[1] Bull. 112 N. J. Ag'l Expt. Station, 1896.

[2] Bull. 40 R. I. Ag'l Expt. Station, Oct. 1896, pp. 89-96.

[3] Bull. 30 R. I. Ag'l. Expt. Station, 1894, p. 79.

rate of four, three, and six pounds, respectively. In each of the first three years of the experiment, sodium chlorid (common salt), where used, was applied at the rate of 6.37 grams, and sodium carbonate at the rate of 5.53 grams per pot.

The seed tubers of 1894 were but slightly scabbed; those of 1895 were practically covered with scab. Both lots were planted without previous treatment with corrosive sublimate or other germicide. The seed tubers of 1896 were not only nearly free from scab, but were treated with 1-1000 corrosive sublimate solution for one and one-half hours.

New Queen seed tubers practically free from scab were planted in 1897, the treatment which they received being indicated in table I. The pots were 26 inches deep, 18 inches in diameter, and were buried in the ground to within about two inches of their tops.

Owing to the rainy season, artificial watering was not required. The results obtained, and such other data as bear upon the experiment, are embodied in the succeeding table.

For the sake of uniformity, the same method of classifying the tubers has been employed as in previous years. Tubers designated as badly scabbed were so seriously affected as to render them unsightly and practically unsalable. Those "slightly scabbed" embraced all of the remainder upon which any trace of the disease was discernible.

While this method of classification is not as detailed as that employed by Arthur,[1] it conveys a very good idea of the extent of the disease, and renders it possible to compare the results of this season with the work of the past, upon a uniform basis. Before attempting to assort the tubers they were thoroughly washed according to the practice in all of our previous experiments in this direction.

[1] Bull. 65 Perdue Univ. Ag'l. Expt. Station, Indiana. pp. 28, 29.

Table showing the Relative Influence of Sulfur and of Corrosive Sublimate Solution in reducing the Amount of Potato Scab.

[In 1897 each pot received 91.9 grams (2½ tons per acre) of air-slacked lime, also 20 grams dried blood, 7 grams nitrate of soda, 10 grams muriate of potash, 20 grams dissolved boneblack, and 10 grams of tankage.]

MATERIALS APPLIED TO THE POTS IN 1894, 1895 AND 1896.	No. of pot.	No. of tubers free from scab.	No. of tubers scabbed.	No. of tubers badly scabbed.	Total No. of tubers.	Per cent. free from scab.	Per cent. scabbed.	Per cent. badly scabbed.
Barn-yard manure and common salt (sodium chlorid)	67*	0	19	10	19	0.0	100.0	52.6
	68†	0	9	7	9	0.0	100.0	77.8
	69‡	2	14	11	16	12.5	87.5	68.8
Barn-yard manure	82*	0	10	10	10	0.0	100.0	100.0
	83†	0	17	14	17	0.0	100.0	82.3
	84‡	2	19	12	21	9.5	90.5	57.1
Barn-yard manure and sodium carbonate	79*	0	12	12	12	0.0	100.0	100.0
	80†	1	16	14	17	5.9	94.1	82.3
	81‡	1	21	16	22	4 6	95.4	72.7
Barn-yard manure, common salt and oxalic acid	64*	0	18	9	18	0.0	100.0	50.0
	65†	0	16	9	16	0.0	100.0	56.3
	66‡	0	15	4	15	0.0	100.0	26.7
Barn-yard manure and oxalic acid	70*	0	14	10	14	0.0	100.0	71.4
	71†	1	14	10	15	6.7	93.3	66.7
	72‡	1	13	9	14	7.1	92.9	64.3
Barn-yard manure, sodium carbonate and oxalic acid	76*	0	11	7	11	0.0	100.0	63.6
	77†	1	18	12	19	5.3	94.7	63.2
	78‡	1	14	13	15	6.7	93.3	86.7

* Seed tubers treated with 1-1000 solution of corrosive sublimate solution for 1½ hours before planting.

† Seed tubers untreated.

‡ Seed tubers rolled in sulfur (5.58 grams per pot, equal to 300 pounds per acre), the balance of the sulfur being dusted over the tubers before they were covered.

It will be seen from the foregoing table that a uniform and fairly large application of lime was made to each pot before the experiment was begun. This was done in order that the conditions might be as favorable as possible to the development of the disease, so as to subject the sulfur treatment to the severest test possible. It must be obvious that a crucial trial of a remedy could not be made where the existing soil conditions were such as to destroy or render inactive the germs of the disease which have been or might be introduced on the seed tubers. Considering the amount of lime applied, and its unquestionable tendency to promote the scab, it is not surprising that no very marked effect of the previous treatment of the soil was noticeable.

In view of the fact that each of the three pots in a given group in the foregoing table had been treated similarly in all respects, the most satisfactory data from which to judge of the merits of the treatments employed are secured by determining, for example, the total number of tubers in all of the pots which were treated with sulfur, also the number of scabbed and badly scabbed tubers in the same, and calculating from the figures thus obtained the average percentage of tubers scabbed and badly scabbed. This has been done in the case of the untreated pots and also where the corrosive sublimate and the sulfur treatment were tried. The results thus obtained are as follows:

	Scabbed tubers. Per cent.	Badly scabbed tubers. Per cent.
Average without treatment................	97	71
" with sulfur treatment...........	93	63
" corrosive sublimate treatment.....	100	69

The first point of interest, as brought out in the foregoing table, and more particularly by the averages just given, is that there was a difference of but two per cent. in badly scabbed tubers between those treated with corrosive sublimate solution and those untreated. In consideration of the now well substantiated fact that the disease, as it chiefly prevails in this country, is caused

by the fungus, first discovered by Thaxter, it is self-evident that the soil must have been contaminated at the outstart or that the germs of the disease were introduced on the seed tubers. Had the disease germs been on the seed tubers rather than already in the soil, then the corrosive sublimate treatment must have diminished the amount of scab to a very great extent, as has been abundantly demonstrated by all who have tried it on uncontaminated or only partially contaminated soils. One is forced, therefore, to the conclusion that the three crops of potatoes which preceded that of 1897, had most effectually contaminated the soil. It will be seen, by comparing the result from the untreated pots with that from those where sulfur was used, that there was a difference of but 4 per cent. in the scabbed tubers and of but 8 per cent. in the badly scabbed ones, in favor of the sulfur treatment.

EXPERIMENT B.

This experiment was conducted in the same pots and with the same soil employed in previous experiments on potato-scab in the years 1894 to 1896, inclusive.[1] The same kind and amount of fertilizer has been applied annually to each of the pots. The formulas used are given below:

	1894. Grams.	1895. Grams.	1896. Grams.	1897. Grams.
Dried blood	21	20	20	20
Nitrate of soda	5	7	7	7
Muriate of potash	10	10	10	10
Dissolved boneblack	25	25	25	20
Tankage	..	..	..	10

The same variety of seed tubers was used in this experiment as in Experiment A. The tubers were washed before attempting to examine them for scab. The other data bearing upon the experiment may be found in the following table:

[1] Bull. 33, R. I. Agr'l Exp't Sta., Oct., 1895, p. 72; also Bull. 40, Oct., 1896, pp. 88-94.

Table showing the Influence of Flowers of Sulfur upon the Development of Potato Scab in soils badly contaminated with the Scab Fungus. (All of the Seed Tubers were treated with 1-1000 Corrosive Sublimate Solution for one and a half hours before planting.)

[Each pot received the same amount of fertilizer, composed of dissolved boneblack, muriate of potash, dried blood and tankage. Lime where used was applied in 1894 at the rate of 2½ tons per acre, and in 1895 at the rate of ½ ton per acre, none having been applied since. The pots receiving calcium compounds were given the same amount of calcium regardless of its form.]

No lime was applied either in 1896 or 1897. Below are shown the forms of lime employed in 1894 and 1895.	No. of pot.	No. of tubers free from scab.	No. of tubers scabbed.	No. of tubers badly scabbed.	Total No. of tubers.	Per cent. free from scab.	Per cent. scabbed.	Per cent. badly scabbed.
Air-slacked lime	29	2	13	12	15	13.3	86.9	80.0
	30	1	9	6	10	10.0	90.0	60.0
	31†	7	16	1	23	30.4	69.6	4.4
Unlimed	34	1	0	0	1	100.0	0.0	0.0
	35	2	0	0	2	100.0	0.0	0.0
	36†	0	0	0	0	0.0	0.0	0.0
Calcium chlorid*	39§	6	0	0	6	100.0	0.0	0.0
	40	1	0	0	1	100.0	0.0	0.0
	41†‡	3	2	1	5	60.0	40.0	20.0
Calcium sulfate.*	44	5	0	0	5	100.0	0.0	0.0
	45	6	0	0	6	100.0	0.0	0.0
(Pure plaster or gypsum).	46†	3	0	0	3	100.0	0.0	0.0
Calcium carbonate*	49	0	14	14	14	0.0	100.0	100.0
	50	3	13	11	16	18.7	81.3	68.8
	51†	0	10	7	10	0.0	100.0	70.0
Calcium oxalate*	61	2	21	21	23	8.7	91.3	91.3
	62	4	13	12	17	23.5	76.5	70.6
	63†	4	14	10	18	22.2	77.7	55.6
Calcium acetate*	75	0	11	11	11	0.0	100.0	100.0
	74†	2	20	19	22	9.1	90.9	86.4
Wood ashes	73	0	22	22	22	0.0	100.0	100.0
	28†	2	9	8	11	18.1	81.8	72.7

* Chemically pure.

† Flowers of sulfur mixed thoroughly with the upper 7 to 8 inches of soil in 1896 before planting. In 1897 the tubers were moistened and rolled in sulfur (5.53 grams per pot or 300 pounds per acre), the balance of the sulfur being dusted over the tubers before they were covered.

‡ Received 44.9 grams of caustic magnesia.

§ Received 91.9 grams air-slacked lime (equal in neutralizing power to 44.9 grams of caustic magnesia).

It will be observed from an inspection of the above table that (excepting pot 41 which received lime in 1897) not a trace of scab was to be found in the pots where calcium sulfate (pure land plaster) and calcium chlorid had been used previously. The same was true also where no lime in any form was applied. This is of particular interest in view of the fact that the seed tubers employed in 1894 were slightly scabbed and untreated with corrosive sublimate solution or other germicide, and that those of 1895 were almost entirely covered by scab[1] and were likewise untreated. It is evident from this that, whether or not the calcium sulfate and calcium chlorid had exerted a germicidal action, the soil conditions naturally existing or induced by the manuring were sufficient to either *destroy* the germs of the disease introduced on the seed tubers in 1894 and 1895 or to render them inactive. As has been stated in our previous publications on this subject, the cause for this peculiar result seems to be attributable either to the acidity of the soil or to compounds which exist in them only when there is a lack of lime or other basic ingredients. On account of the fact that no scab appeared in the groups of pots mentioned above, they cannot of course throw any light upon the probable efficacy of the sulfur treatment.

The poisonous action of the calcium chlorid upon the potatoes, not only in the years when this compound was applied, but also in the subsequent ones, has been of marked interest. The question naturally arose as to whether this injury was attributable directly to a poisonous action of this calcium salt or was, perhaps, caused indirectly by a dissociation or breaking up of the compound by which chlorine or hydrochloric acid was liberated. In the latter case it was conceivable that the addition of carbonate of lime, caustic magnesia, or other compounds possessing the ability to combine with acids, might prove beneficial. For the purpose of testing the matter, the calcium chlorid pot (41), which received sulfur in 1896 and 1897, was treated with 91.9 grams of

[1] Bull. 33, R. I. Ag'l. Expt. Sta., Oct. 1895, page 73; illustration, Fig. 2.

air-slacked lime. In 1896, when sulfur was applied without lime, the growth of the vines seemed to be even poorer than formerly, but in 1897, after liming, they made a very good growth, and it was strikingly evident that the lime partially or wholly overcame the ill effect of the calcium chlorid. A similar, though slightly less striking result, was obtained by the use of caustic magnesia[1] (pot 39). It will be seen that there were five tubers in the limed pot and six in the one receiving caustic magnesia, while in that without treatment there was but one. Moreover, in the pots where no lime compounds had been employed, in one instance, though the plants made some growth, there were no tubers; in another, but one; and in the third, but two tubers were obtained. From this it is evident that the ill-effect of the calcium chlorid had been more than overcome, and the results were closely in accord with those where calcium sulfate had been employed by itself as a form of lime.

In 1896 no particular ill effect from the use of sulfur (600 pounds per acre) was discernible. In 1897, however, a quite marked inferiority of the plants was apparent in the pots of the unlimed and calcium sulfate groups which had had the sulfur treatment, the former of which produced no tubers and the latter but three. A positive ill effect from the use of sulfur was not noticeable where wood ashes, calcium carbonate (carbonate of lime), or other forms of lime readily convertible into the carbonate in the soil, had been used. This fact is, at least, indicative that the injurious action of the sulfur in the other cases may have been due to its slow oxidation and the consequent production of free acid in the soil.

Since the same manuring has been employed in all of the pots embraced in the experiment, and as the amount of lime applied previously, whether in the form of air-slacked lime, wood ashes, or the lime salts, was, in each case, equivalent to a like amount of calcium oxid, the number of scabbed and badly scabbed tubers, as well as the total number from pots 31, 51, 63, 74, and 28 have

[1] The quantity of caustic magnesia (44.9 grams) was sufficient to neutralize the same amount of acid as 91.9 grams of air-slacked lime, the amount used in pot 41.

been combined, in calculating the average amount of scabbed and badly scabbed tubers from the pots treated with sulfur.

Averages for the untreated pots 29, 30, 49, 50, 61, 62, 75 and 73, were calculated in a corresponding manner. The following averages were thus obtained:

	Scabbed Tubers. Per cent.	Badly scabbed Tubers. Per cent.
Average without treatment	91	85
" with sulfur treatment	82	54

It appears from the above results that there was a reduction of 31 per cent. in the number of badly scabbed tubers where the sulfur treatment had been used. The sulfur was applied, in 1896, at the rate of 600 pounds per acre, and, in 1897, at the rate of 300 pounds, making a total application of 900 pounds for the two years. The high percentage (in three instances amounting to 100 per cent.) of badly scabbed tubers from the pots not treated with sulfur furnishes conclusive evidence of the previous contaminated condition of the soil. This point is still further emphasized in view of the fact that the seed tubers were treated with corrosive sublimate, a treatment which is highly effective in reducing the amount of the scab in the case of uncontaminated or but slightly contaminated soils.

Having considered in detail the results secured in two years' trial of the sulfur treatment, it may be of interest to note the results that have been obtained by others.

In 1896 attention was called[1] to the fact that Halsted[2] claimed the sulfur treatment to be an efficient remedy for potato scab in badly contaminated soils. It was pointed out, however, that his own data proved conclusively the contrary of what he apparently assumed, that the soil at Freehold, N. J., was not badly contaminated, for, otherwise, his treatment of the seed tubers with corrosive sublimate could not have reduced the amount of scab to 1 per

[1] Bull. 40, R. I. Ag'l Exp't Sta., Oct. 1896, pp. 89, 90.

[2] Bull. 112, N. J. Ag'l Exp't Sta., 1895.

cent. In regard to the New Brunswick soil he states that it was one in which the scab fungus was not known to exist. It must be evident, therefore, that his results, obtained under such circumstances, could throw no conclusive light whatsoever upon the probable efficacy of the sulfur treatment for contaminated soils.

In 1896 Halsted[1] still further pursued his experiments upon the same area devoted to the investigation in 1895. In view of the scab on the crop of 1895 there remained no doubt that at the beginning of the 1896 experiment the soil must have been in a badly contaminated condition. According to his results in 1896, taking two sections which (in the absence of any statement in relation thereto) were, presumably, manured alike and treated the same in every other respect, except for the application to the soil of one, of 300 pounds of sulfur per acre in 1895, it appears that the scab was reduced by the single sulfur treatment of the previous year from 90 to 5 per cent.

Brooks[2] tried an experiment in a soil known to have been contaminated at the outset. Sulfur, at the rate of 300 pounds per acre, was sprinkled in the rows when the seed tubers were planted. In one case the tubers planted with and without the use of sulfur had been subjected to a preliminary treatment with corrosive sublimate solution and in the other they had not. No data are given in relation to the "small" tubers, but the number of pounds of large ones, free from scab, slightly scabbed and badly scabbed, is given. In the case of the treated seed tubers 8 per cent. more, by weight, of badly scabbed large tubers was obtained where the sulfur was used than where it was not. With the untreated tubers it is impossible to calculate exactly the per cent., owing to the fact that the weights of the tubers free from the scab were not given. However, since there were but two tubers in one case and three in the other, and because the weights of slightly scabbed and badly scabbed ranged from 67 to 96 pounds in each case, it gives an approximately correct percentage to omit them from the calcu-

[1] Bull. 120, N. J. Agr'l Exp't Sta., pp. 1-7.

[2] 9th An. Rp't Hatch Exp't Sta. of the Mass. Ag'l College, January, 1897, pp. 44, 45.

lation. Thus calculated there was a difference of but 6 per cent. in favor of the sulfur treatment.

From what has preceded it must be evident that Halsted's 1896 results are the only ones which he has obtained that can serve to throw any light upon the probable efficacy of the sulfur treatment for preventing potato scab in contaminated soils.

The data obtained by Brooks are too conflicting to permit one to draw any conclusions from them. Our own results in 1896, where 600 pounds per acre of sulfur were used, were merely indicative and not at all conclusive as to benefit from its use. In 1897, where 300 pounds of sulfur per acre were used, the number of badly scabbed tubers was reduced but 8 per cent. With an application of 600 pounds per acre of sulfur in 1896, and 300 pounds additional in 1897, the number of badly scabbed tubers was reduced but 31 per cent. The indications are that the sulfur treatment of contaminated soils may decidedly reduce the percentage of scab if enough sulfur is employed and the moisture and other soil conditions are such that it is able to exert its maximum effect. In consideration of the cost of sulfur if applied in large quantities, and owing to the fact that it can have little or no indirect manurial action, it is of interest to compare the results secured by it with those secured formerly at this Station by the use of sulfate of ammonia, which is one of the important forms in which nitrogen is employed manurially.

The data which follow were obtained in the field, upon plots 25 and 29. Each plot received air-slacked lime, in 1893, at the rate of 5,400 pounds per acre, and again, in 1894, at the rate of 1,000 pounds per acre. Equal annual applications of dissolved boneblack, muriate of potash and nitrogen, were made, beginning in 1893. Upon plot 25 nitrogen was applied in the form of sulfate of ammonia, and upon plot 29 as nitrate of soda. In 1893, the first year of the experiment, no particular difference in the percentage of scab was noticeable. In 1894 the results were as follows:

(1) By use of treated seed tubers:

	Sulfate of ammonia. Per cent.	Nitrate of soda. Per cent.
Potato tubers free from scab	62.5	50.9
" " scabbed	37.5	49.1
" " badly scabbed	5.9	5.3

(2) By the use of untreated seed tubers on a line across the plots where potatoes had not been previously grown:

	Sulfate of ammonia. Per cent.	Nitrate of soda. Per cent.
Potato tubers free from scab	45.3	28.7
" " scabbed	54.7	71.3
" " badly scabbed	4.2	21.7

(3) By use of untreated seed tubers and grown on the location of a previous potato row of 1893, in which untreated seed tubers were also used:

	Sulfate of ammonia. Per cent.	Nitrate of soda. Per cent.
Potato tubers free from scab	0.0	0.0
" " scabbed	100.0	100.0
" " badly scabbed	53.9	88.8

In 1895 the experiment was continued, with the results embodied in the following table:

Table showing the Relative Effect of Sulfate of Ammonia and Nitrate of Soda upon the Development of Potato Scab, when each is used in connection with like quantities of Dissolved Boneblack, Muriate of Potash and Air-slacked Lime.

FORMS OF NITROGEN.	Treatment of Seed Tubers.	Location of Rows.	Per cent. of tubers free from scab.	Per cent. of tubers scabbed.	Per cent. of tubers badly scabbed.
Sulfate of ammonia..	Tubers treated*..	On line of row grown from treated seed tubers in 1894.	40.0	60.0	28.0
Nitrate of soda.....	Tubers treated...		48.0	52.0	24.0
Sulfate of ammonia..	Tubers untreated.		30.0	70.0	10.0
Nitrate of soda......	Tubers untreated.		0.0	100.0	75.0
Sulfate of ammonia..	Tubers treated*..	Near line of row grown from untreated seed tubers in 1894.	15.0	85.0	45.0
Nitrate of soda......	Tubers treated...		9.5	90.5	85.7
Sulfate of ammonia..	Tubers untreated.		29.2	70.8	45.8
Nitrate of soda.. ...	Tubers untreated.		0.0	100.0	84.2
Sulfate of ammonia..	Tubers treated*..	On line of rows grown in 1893 and 1894 from untreated seed tubers.	14.3	85.7	71.4
Nitrate of soda......	Tubers treated...		0.0	100.0	100.0
Sulfate of ammonia..	Tubers untreated.		0.0	100.0	81.5
Nitrate of soda......	Tubers untreated.		0.0	100.0	100.0
Sulfate of ammonia..	Tubers treated*..	On line of row grown in 1894 from untreated seed tubers.	39 1	60.9	26.1
Nitrate of soda......	Tubers treated ..		29.2	70.8	29.2
Sulfate of ammonia..	Tubers untreated.		54.2	45.8	12.5
Nitrate of soda......	Tubers untreated		10.3	89.7	72.4

* With a 1-1000 solution of corrosive sublimate for 1½ hours.

It will be seen from the foregoing that the percentage difference in the number of badly scabbed tubers, obtained by comparing the amount of scab upon the sulfate of ammonia plot with that upon the nitrate of soda plot, amounted to 34.9, 65.0, 38.4, 59.9 in four cases where untreated tubers were used upon previously contaminated soil. While the soda of the nitrate of soda

may have and undoubtedly did exert some influence in favoring the development of scab, it seems probable that the sulfate of ammonia was an important factor on the other hand in diminishing it. In order to determine in our soil the exact effect of this substance, it would be necessary that one plot should receive no nitrate of soda, and the other sulfate of ammonia. This could hardly be accomplished, owing to its need of nitrogen, without supplying organic nitrogen in some form, which would have to be applied to both plots in order to maintain exactly uniform all the conditions aside from those due to the sulfate of ammonia.

Owing to the favorable promise of sulfate of ammonia for use on contaminated soils, and in view of the fact that it is valuable as a fertilizer and probably is to become, another season, much cheaper than sulfur, it is hoped to conduct further experiments in the line just designated.

SUMMARY.

1. The results of 1897 fully confirm those of previous years as to the tendency of carbonate of lime, and all combinations of lime which are changed into that form within the soil, to promote in a striking degree the development of the potato scab.

2. On a badly contaminated soil the use of sulfur, for two consecutive years, in quantities amounting in all to 900 pounds per acre, reduced the amount of scab in a decided degree.

3. Owing to the cost of sulfur, and the improbability of its being of more than slight, if any, indirect manurial value, it appears possible that the employment of sulfate of ammonia, which is at the same time a valuable source of nitrogen, might prove more economical than sulfur in reducing the tendency to scab on soils already contaminated with the scab fungus. The results thus far secured indicate that if it were employed in connection with kainit, sulfate, or muriate of potash, soils would be rapidly improved in this particular.

4. Owing to the fact that soils naturally favorable to the development of the potato scab are also favorable to nitrification, the fullest manurial action of the sulfate of ammonia should be obtained.

HORTICULTURAL DIVISION.

L. F. KINNEY.

Three bulletins have been prepared for publication by this division during 1897. The first of these, No. 43, "Additional Tests of Garden Seeds" (13 pages), was issued in January; the second, No. 44, "Celery and its Cultivation in Rhode Island" (50 pages and 20 illustrations), was issued in March; the third, No. 45, "The Loganberry, From Seed to Fruitage" (22 pages and 9 illustrations), was issued in April. An account of other work which has been completed is included in the three following articles, which are submitted as a part of this report.

GARDEN LETTUCE AND ITS CULTIVATION.

L. F. KINNEY.

This vegetable is peculiarly interesting because its cultivation as now practiced in great glass houses represents a higher form of agriculture than any known to previous generations. It is impossible to tell just how much better the best lettuce of the present time is than the best lettuce that was grown a few hundred or a few thousand years ago, but certainly the average quality of lettuce is very much better now than it was ever before. Formerly, the cultivation of choice lettuce was confined to private gardens of small area, but now hundreds of acres, planted with the most highly improved varieties, receive as intensive culture as is given to any other horticultural crop. Probably nowhere else in this country, if indeed in any country, is lettuce grown either more systematically or better than here in Rhode Island. It is upon the large vegetable farms that this work has reached its highest development, and this, too, in the growth of the winter rather than the summer crops.

That lettuce is grown here extensively is shown by the fact that the sales of this vegetable from a single farm during the last fifteen years have amounted to over half a million dollars. Less than four years ago it was estimated that fully nine-tenths of the winter head-lettuce sold in New York and other eastern markets was grown either in Rhode Island or in the vicinity of Boston.*

Whatever fortune has had in store for those who have cultivated

* Galloway *Agricultural Science*, Vol. 8, p. 304.

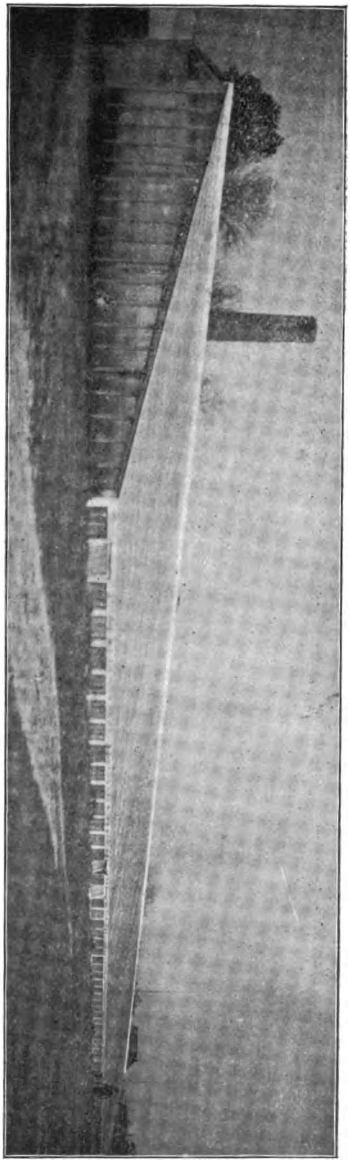

FIG. 1.—One of Mr. C. H. Paine's lettuce houses, 375 x 81 feet, covering about one-fourth acre.

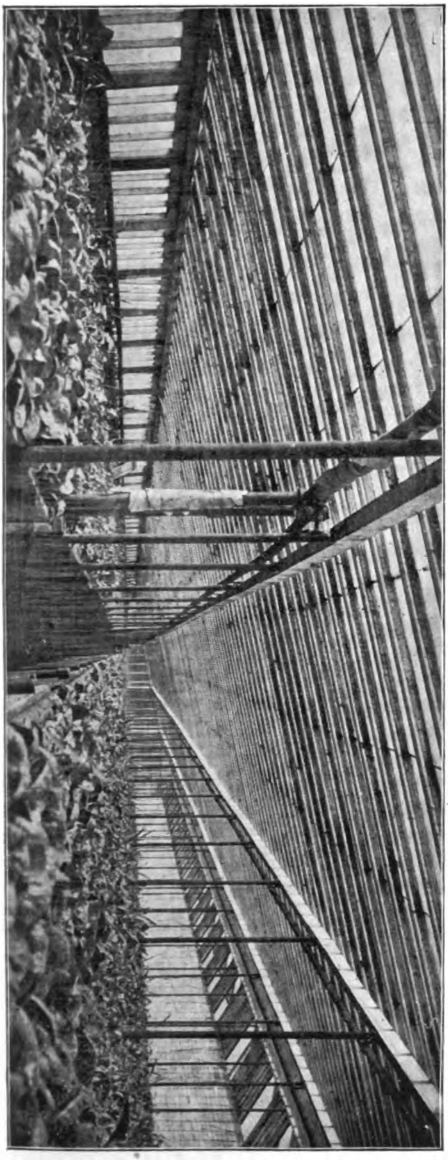

FIG. 2.—Interior view of Mr. Paine's lettuce house.

other crops in these localities during the last quarter of a century, there is no doubt but what the cultivation of winter lettuce in them has been attended with remarkable success both as a business venture and in establishing improved methods of cultivating garden plants. We are particularly glad to note this, because, while the ornamental gardening at Newport has been admired by representatives from every State in the Union, it is not generally known how successfully vegetables are cultivated here on a large scale. There is no doubt that this success is partially due to the central location of the Rhode Island vegetable farms between the great markets in New York and Boston, and with the second largest city in New England within the borders of the State, and the third near by.

Climate, also, is an important factor. The atmospheric conditions here are peculiarly favorable to the growth of some plants. This is shown by the native flora. Within 10 miles of the Experiment Station there are hundreds of acres of land densely covered with the wild rhododendron (*R. maximum*); and the prickly-holly (*Ilex opaca*), although less abundant, is not uncommon in some localities. Neither of these species is generally disseminated in New England, and their presence here and the luxuriance with which they grow, speak well for the Rhode Island climate. The location and climate here are to be regarded as important natural advantages which have favored the growth of winter lettuce and spinach on a large scale. It remains to be demonstrated that fruit can be grown here as extensively and profitably as vegetables have been by taking advantage of the natural conditions.

MODIFICATION OF FORM BY CULTIVATION.

It has been said that the very structure of agriculture depends upon the ability of plants to vary in form when an excessive food supply becomes available to them, and perhaps there are no plants which illustrate the extent of such variations better than the garden vegetables.

Among these there are familiar examples of fleshy enlargements of roots, stems, leaves, and even of the inflorescence, and we regard the form of these enlargements as constituting more or less fixed characters of varieties. It should be understood that often such characters only exist where there is a peculiar environment. This is obvious in the case of the varieties of lettuce.

Take for example, the Boston Market. It is described as a close-heading kind, with broad, thick, crumpled and folded leaves, but it is anticipated in this description that the plants have the advantage of garden cultivation, otherwise it would not apply in a single particular. All of these so-called characters remain perfectly dormant in plants when grown on infertile soil. Under such conditions the plants exhibit no tendency to form heads; the leaves are narrow, thin, and not at all crumpled or folded, yet normal flowers and seeds are produced. We are justified, then, in concluding that here the peculiar phenomenon called "heading," together with the thickening and folding of the leaves, is brought about by cultivation.

The changes which go on within the plants are obscure, but, as near as we can make them out from external observations, they are not unlike those that are associated with the fattening of animals. They are clearly influenced and in a measure limited by heredity, but they take place largely by virtue of the ability of the plants to absorb and assimilate an excessive amount of nutritive substances, and this, in turn, depends upon the environment. There, are then, in all highly developed plants, like the Boston Market lettuce, two primary co-efficients, which together determine the form of the parts, viz.: the co-efficient of variety and the co-efficient of environment. The existence of the former is shown by the fact that the Boston Market and Asparagus Cos lettuces always have differently shaped leaves when grown side by side, and the influence of the latter is equally evident when a poorly nourished black-seeded Tennis Ball plant is compared with one of the same kind that has been highly cultivated. One is a frail plant like the mustard, while the other is stout, with

thickened leaves that are closely folded into a head like the cabbage.

It is here, then, that the inquiry concerning the principle underlying the profitable cultivation of lettuce should begin, because it is the particular form which lettuce plants assume, and not alone their bulk, that determines their economic value. The demand is for lettuce heads, the inner leaves of which are blanched as white as the stalks of celery, and, even more than this, there must be no open spaces in the heads through which the air can circulate.

FAILURE OF LETTUCE TO HEAD.

Despite the established habit of the famous Tennis Balls and other standard varieties of lettuce to form firm heads, it is well known that they often fail to do it. When this occurs the cause can usually be traced to one of two conditions; viz., either to the inability of the plants to absorb or to assimilate an adequate amount of nutritive substances. The former is usually due to an insufficient amount of available fertilizing ingredients in the soil, and the latter to an insufficient amount of light, a condition which frequently occurs during the winter, when the plants are necessarily grown under glass.

The effect of different degrees of fertility of the soil upon the form of lettuce plants was well illustrated in the Station garden last summer, where, in one case, 84 kinds of lettuce were planted on both very rich and moderately poor soil.

Although the principal heading varieties were included in this collection, not one of them produced a well formed head upon the soil that was lightly fertilized. Upon the part of the field where there was an abundance of available plant food (it having been prepared for the crop by an application of stable manure at the rate of 30 cords to the acre, and Stockbridge's vegetable manure at the rate of one ton to the acre), the leaves of many of the kinds folded together so tightly that blossom stalks were rarely produced, except where the heads were cut open to allow them to push up

through. These plants were grown outdoors, where the light was unobstructed.

In lettuce-houses and frames, even of modern construction, the intensity of the light is considerably reduced, and this noticeably affects the heading of the plants. In fact, many kinds which head uniformly in the field, obstinately persist in refusing to do so when grown under glass, even though the soil is made intensely fertile.

CULTIVATION OF LETTUCE IN THE OPEN AIR.

Lettuce plants occasionally survive the winter in Rhode Island without protection. It is noticeable that the names of inferior kinds of lettuce, which were formerly grown in this country and are still largely grown in Europe, mainly on account of their hardiness, have now nearly disappeared from the catalogues issued by American seedsmen. The Brown Dutch is about the only exception. Plants of the more highly developed kinds, which are represented by the black-seeded Tennis Ball, Iceberg, Prize Head, etc., when started under glass in March and set in the field when freezing weather is mainly over in the spring, mature earlier and yield a better product than plants that are started in the fall and wintered out of doors. Hardiness, or at least ability to endure extreme cold weather, is no longer regarded as an important attribute of a variety of lettuce in New England. The quality of outdoor lettuce is extremely variable, and determined largely by the preparation of the soil, which must be made very rich to produce first-class heads, or crisp and blanched leaves on the non-heading varieties. There is not a kind of lettuce among many varieties cultivated capable of producing a superior product on a poor soil. Lettuce also thrives better in the cool spring and fall weather than during the summer months. Successive plantings of the seed are made from the first of May until July. The heads are in condition for cutting in from 12 to 14 weeks after the seed is planted, but the heading varieties do not remain in this condition more than one or two weeks before the blossom

stalks start. In quality the black-seeded Tennis Ball is still the standard of excellence. It is extensively grown in market gardens. The Early Curled Silesian or Simpson is a popular non-heading kind, but is grown mainly for private use. The Iceberg, New York, Hanson, and Deacon, all heading varieties, are grown on a small scale both for private use and for market. The merits of the Cos lettuce are not yet generally recognized. This kind seems to require even richer soil than the black-seeded Tennis Ball to form good heads. When the soil is properly prepared the heads are very large and firm, and the leaves are white, crisp and free

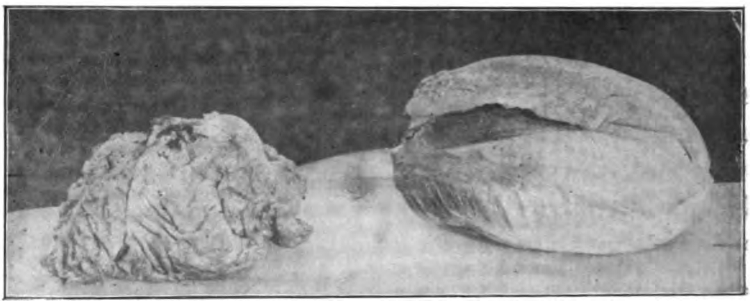

FIG. 3.

Head of B. S. Tennis Ball Lettuce. Weight 11 oz.

Head of Paris White Cos Lettuce. Weight 1 lb.

from bitterness. The Paris White Cos is the standard variety of this class. The Trianon Cos and the Paris Self-Folding Cos are slightly modified forms of the above, but are scarcely distinguishable either from it or from each other. In order to insure firmness of the heads it is customary to tie the leaves of the Cos lettuce together one or two weeks before the heads mature. This operation is not always necessary.

The ordinary garden fertilizers are adapted for the production of lettuce, but, as already stated, two or three times as much of them should be applied as is necessary for the growth of beets, cabbages, and most other garden vegetables.

CULTIVATION OF LETTUCE UNDER GLASS.

Lettuce appears to be the first crop that was grown extensively under glass by market gardeners. We do not know exactly when this mode of culture began, but it certainly was practiced fifty years ago.* It was the custom then to sow lettuce seed in the open ground in September, and transplant the seedlings to frames early in October. The frames were covered with sashes when necessary, to prevent the ground from freezing too hard, but the sashes were either raised or removed in warm days. The plants remained nearly dormant until March, when they gradually started into growth and matured about the middle of April—a month or more in advance of the outdoor crop. This method began to be modified between 1850 and 1860. Instead of planting the seed in the field, it was sown rather thinly in frames—about the 20th of September. The plants remained until the first of March in these frames, then they were transplanted to other frames, where the soil had been freshly prepared. The lettuce grown in this way matured as early as when it was transplanted in the fall. It required less labor to take care of the plants during the winter, and it was more tender, because the main growth was in the spring, while before, many of the large leaves were wintered over. Artificial heat was not provided in the early days of cultivation of lettuce under glass, but after 1860 we find accounts of hot-beds coming into use in market gardens. At first they were not started until March, and only one crop of lettuce was grown in them. Later it was found that they could be used through the entire winter, and that three crops of lettuce could be grown in them by putting in as many fresh lots of manure. This is the way winter lettuce was grown twenty-five years ago, and it was estimated at that time that no less than 50,000 sashes were used mainly for this purpose within ten miles of Boston.† Boston lettuce was

* Peter Henderson, *Country Gentleman*, 1895, Vol. xiii, p. 63.

† W. D. Philbrick, *Country Gentlemen*, 1872, Vol. 37, p. 134.

then a standard article in New York markets, and it was often sent to Philadelphia and Baltimore.

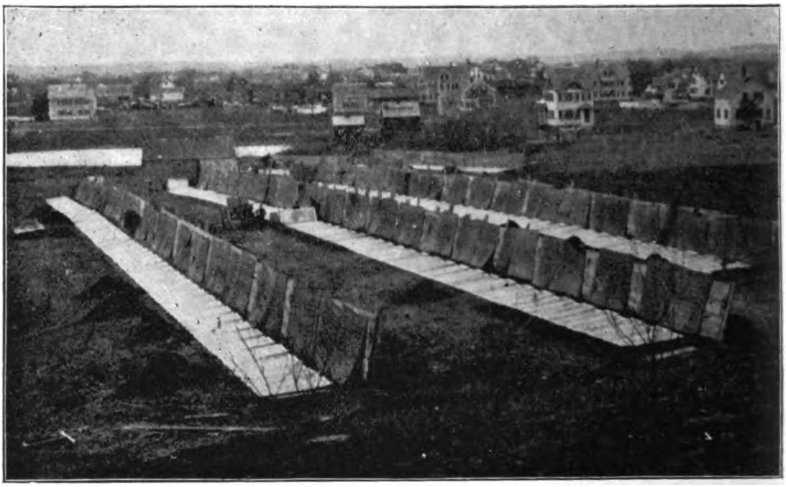

FIG. 4. Ranges of hot-beds owned by Mr. Daniel Potter, Auburn, R. I., and used for growing winter lettuce.

In 1873, a few market gardeners were growing lettuce in greenhouses. They were convinced that it could be grown with less expense in this way, but they generally failed to produce uniformly first-class heads.* The lettuce-houses at that time were clumsy structures. They were generally covered with hot-bed sashes. Often the sashes were taken off and packed away during the summer. The larger glass-houses that have been built for forcing lettuce during the last ten or fifteen years are of quite a different pattern. They are glazed on permanent sash bars, large lights of glass are used, 16 x 24 inches being a popular size. Iron pipes are largely used as supports, so that a great deal more light enters the modern lettuce-houses than it was possible to secure by the earlier methods of construction.

* W. D. Philbrick, *Country Gentleman*, 1873, Vol. 38, p. 374.

FIG. 6.—Interior view in Mr. J. F. Jordan's model lettuce house, Auburn, R. I.

The progress in heating lettuce-houses during the last 25 years has been equally noteworthy. Fermenting manure was used at first, the same as in frames, but supplemented by hot-air flues. In 1888 the use of manures for heating purposes in the lettuce houses had been mainly abandoned by market gardeners in the vicinity of New York, and lettuce growers were then heating their houses with flues.* The flue system was soon superseded in the larger establishments by hot water, and this, in turn, by steam, which is now usually generated in a single large plant and conducted in pipes to the various houses. The steam is distributed in the houses through wrought iron pipes, varying in diameter from one to three inches. The 1¼-inch size is preferred for radiation, although 1-inch pipe has been largely used. Considerable difference in opinion exists about the best arrangement of the pipes in the houses, but generally three lines of pipe are placed under the roof and two just above the soil at the ends and along the front side. Sometimes there are pipes also along the walks. The heat, in rising from the lower pipes, does more or less damage, and for this reason there is an increasing disposition among lettuce growers to place all of the heating pipes well above the beds.

Starting the Plants.—The seed for the first crop is mainly planted in September, about the middle of the month or a little later; occasionally earlier plantings are made in August. The seed is sown broadcast, frequently in frames, but the frames are not covered with sashes. When plants are large enough to handle conveniently, or when they are three or four weeks old, they are transplanted from the seed-bed to the lettuce-house or to other frames. Plants for the later crops are transplanted twice, being set first two or three inches apart and then seven and one-half to eight inches apart, according to the variety. For the first crop the plants are often set in the frames or houses where they are to mature, directly from the seed-bed.

Preparation of Soil.—The soil used in growing winter lettuce is

* Wm. Falconer, *Country Gentleman*, 1888, Vol. 53, p. 946.

prepared with unusual care. It is mixed up fresh at the beginning of each season and thrown out of the houses or frames and carted away the following summer. These operations involve considerable expense, but at present they seem to be necessary to secure the best results. Yellow loam from beneath the surface soil on uncultivated land is preferred as the basis of the new soil. This is shoveled into the beds, first to the depth of six inches or more, then about one-half as much rather fresh stable manure is spread evenly over it, and the soil in the whole bed is forked over. Only the upper foot of the soil in the beds is usually removed, but the newly prepared soil in them is mixed with the old, the fresh ingredients being worked deep down into the beds. This encourages a deep root growth which is an important safeguard against the "leaf-burn." It is the aim, in preparing the soil for the lettuce crops, to make the plants grow both quickly and large, and in order to do this commercial and other fertilizers are often used in addition to the stable manure.

Care of the Crop.—Lettuce requires comparatively little cultivation when grown under glass, but the temperature and ventilation are sources of constant anxiety. It is well known that unless the atmospheric conditions are about right the plants will not form good heads, no matter how carefully the soil is prepared. A night temperature of about 45° Fahr. and a day temperature 30 or 40 degrees higher, with considerable fresh air and strong light, are preferred. All of the factors which influence the atmospheric conditions are not entirely under the control of the grower. For example, several cloudy days often occur in succession, and the light in the houses is reduced. There should be a corresponding reduction in the day temperature, and, perhaps, more ventilation than during clear weather. It is impossible to determine in advance just how high it will do to have the temperature in a lettuce-house or what ventilation will be necessary. These are matters which require the exercise of judgment, day and night, from the time the plants are set until they are mature, which is usually from 6 to 8 weeks. It is hardly necessary to state that

improper attention to them is the most frequent cause of the mildew, rot, and the leaf-burn, and also the failure of the plants to head. Certain fungi are associated with both the mildew and the rot,* but it is doubtful if, in either case, the fungi often attack uninjured tissues. When the cells become water-soaked the rot-fungus, at least, may gain entrance and become an active parasite.† The sudden appearance of the rot is a pretty sure indication that at some time, not long before, the temperature in the house had been too high and the soil too wet. The lettuce mildew, like other mildews, usually indicates a too sudden change from a high to a low temperature. Such a change causes stagnation of the normal activities of the cell contents, which seems to be favorable for the spread of the mildew, particularly in a damp atmosphere. The progress of the mildew can, however, be appreciably checked by the use of sulfur, either sprinkled upon the steam pipes or, better, evaporated over a kerosene stove. In the latter case great care must be taken to prevent the sulfur from burning, as the fumes are incomparably more destructive than the mildew-fungus. The danger from this source is reduced by placing the basin or kettle containing the sulfur in another receptacle having a half-inch of sand in the bottom. This makes a sand-bath, which distributes the heat. Even with the bath the stove needs considerable attention.

The "top-burn" is a physical injury which seems to be due to excessive heat. The edges of the inner leaves wilt first, and if this continues long the cells collapse and die. This is most likely to occur during a period of high temperature or where the plants are too near steam pipes. Too porous a soil may cause it. Leaf-burn does not usually occur until the heads begin to form, and it is not necessarily followed by decay of the tissue below the injured cells. The plants never entirely outgrow it, although they may be marketable at a reduced price.

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* *Perinospora gangliformis* with lettuce mildew.
Botrytis vulgaris with lettuce rot.

† Galloway, *Agricultural Science*. Vol. viii, p. 314.

Varieties Grown.—The white-seeded Tennis Ball or Boston Market is the variety that the growers here started with a quarter of a century or more ago, and it is still grown exclusively in the largest houses. The seed has been grown year after year upon some farms, and it has not run out. On the contrary the variety seems to have steadily improved. The plants are set 7½ inches apart each way, and, under favorable circumstances, they head uniformly, maturing earlier than any other kind producing equally large heads. The superior table qualities of this variety have been recognized for many years. There is, however, a demand for larger heads of lettuce in the markets, and two other kinds are now grown extensively under glass in Rhode Island. These are the Big Boston, a kind resembling the white-seeded Tennis Ball but larger, and another variety with longer leaves, which are slightly curly upon the sides. The latter kind is considered the more promising of the two, and, when well grown, five dozen heads of it fill a barrel, while it takes six or seven dozen heads of the white-seeded Tennis Ball. It is also thought that the plants of the new kind are less subject to injury from the mildew and the leaf-burn than those of the Tennis Ball. The larger plants are set a little farther apart, about 8x8 inches, and they mature slowly—we should think that nearly four crops of the Tennis Ball could be grown in the time required by three crops of the larger lettuce. There is yet some doubt, therefore, about the new kind being, on the whole, better than the old. This lettuce is readily distinguished from the Tennis Ball by its longer leaves, which are slightly curly on the edges, and a lighter shade of green. The leaves also have sharp projections on the sides, particularly near the base, while those of the Tennis Ball are nearly smooth. It resembles the Tennis Ball in having the ends of the leaves shaded with red.

Preparation for Market.—Under the skillful management which the lettuce-houses receive, there is a wonderful uniformity in the growth of the plants—they look as if they were all cast in the same mould. When the time comes to market the crop, all of the

SCENES AT THE BUDLONG FARM.

FIG. 6. Pulling lettuce in glass house. 500 feet long.

FIG. 7. Washing and packing winter lettuce.

FIG. 8. Carting winter lettuce to the boat. Sixty-two barrels, about one-quarter of a single day's shipment.

plants in a frame, or even in a whole house, are often pulled at the same time, so that the soil can be immediately prepared for another crop. The earth is shaken from the roots, and if there are any bad leaves they are picked off. The plants are roughly sorted into two or three grades and placed in barrels or boxes. From the house or frame the plants go to the packing room, where they are washed in great tanks supplied with running water. When taken from the tanks the plants are placed on slat-racks, with the heads down, to allow the surface water to drain off. They are again sorted, as they are placed in bushel boxes if for the local market, or placed in barrels and headed up if to be shipped away.

CLASSIFICATION AND DESCRIPTION OF THE VARIETIES OF GARDEN LETTUCE.

L. F. KINNEY.

The older descriptions of the varieties of lettuce are incomplete, like those of most of the other garden vegetables, in that they do not point out how each particular variety differs from every other variety. The limits of variation are not clearly defined, and, therefore, kinds without pronounced characters cannot be determined with any satisfactory degree of accuracy. The result is that there is no end to the confusion of names.

A major proportion of the illustrations of lettuce are quite as bad as the descriptions. They have been made for advertising purposes, and such parts as it has seemed desirable to make prominent have been exaggerated, while often important characters have been entirely omitted. In trade publications the same figure is not infrequently used to represent one variety in one place and quite a different one in some other place.

It has been said that this is unavoidable, because the characters of such plants as the garden lettuce are not sufficiently permanent to warrant a systematic classification of the varieties. This supposition does not, however, seem to have ever been proven. The facts are that certain traits have served as distinguishing characteristics for races of lettuce for centuries, and these traits are evident still. Familiar examples of them are the peculiar habit of growth of the Cos lettuces; the presence of red pigment in the tissues of some kinds, while it is always absent in others; the curling of the margins of the leaves and the color of the seed.

Such traits as these may, of course, be bred out, but the tendency is for them to be reproduced. Then there is the history of the white-seeded Tennis Ball. This variety seems to have retained its individuality for fully a half a century. At least the name has been constantly used during that time, and it probably will continue to be for many years longer. There are other old kinds that are still grown.

If, then, both characters and names are associated together for long periods, a systematic classification of the varieties is just what is needed to obviate confusion.

Descriptive lists of the varieties of lettuce have been published* but it is believed that there has been no recent classification of the varieties based entirely upon the botanical characters. The kinds have been grouped as spring, summer, and winter; and as cabbage, cutting and Cos lettuces, and then the names arranged in alphabetical order, but with this disposal any change in a name of variety is sure to lead to confusion. In the arrangement adopted in the following pages the position of a kind of lettuce is approximately determined by certain botanical characters irrespective of the name. The descriptions of kinds which closely resemble each other are placed close together so that they can be readily compared and the minor differences noted. All of the descriptions have been prepared from carefully selected, well grown specimens. The illustrations are mainly from photographs, and therefore rich in detail and unquestionably accurate.

Altogether, the plants from more than a thousand separate plantings of lettuce seed secured from leading seedsmen in the East, South, North and West, and also from Canada, England, and France, have been available for the study of this species. The primary object in bringing the large collection of kinds together was to have ample material at hand to settle any questions which might arise regarding either the methods of cultivation or the comparative

* Vilmorin.—The Vegetable Garden, Eng. Translation by Robinson.

Burr.—The Garden Vegetables of America.

Goff.—Fourth Annual Report of the N. Y. State Experiment Station.

merits of varieties. The latter subject is of especial interest at this time because there is an urgent demand for an improved forcing variety. A survey of the kinds already in existence has failed to reveal one that satisfactorily fulfills the requirements, yet it is not improbable that such a variety will be originated in the immediate future. This may not come from any of the kinds that are popular for forcing at the present time, but be an offshoot from a distinct form—possibly from the Cos type. These plants form large heads, and, on account of their peculiar upright habit of growth, they can be planted closely together.

The present kinds of Cos lettuce would not probably head well when grown indoors, due to the reduced intensity of the light, but this shortcoming might not be permanent. Inadequate glass structures have prevented any experiments along this line here, although seed has been distributed among those interested in this subject for this purpose.

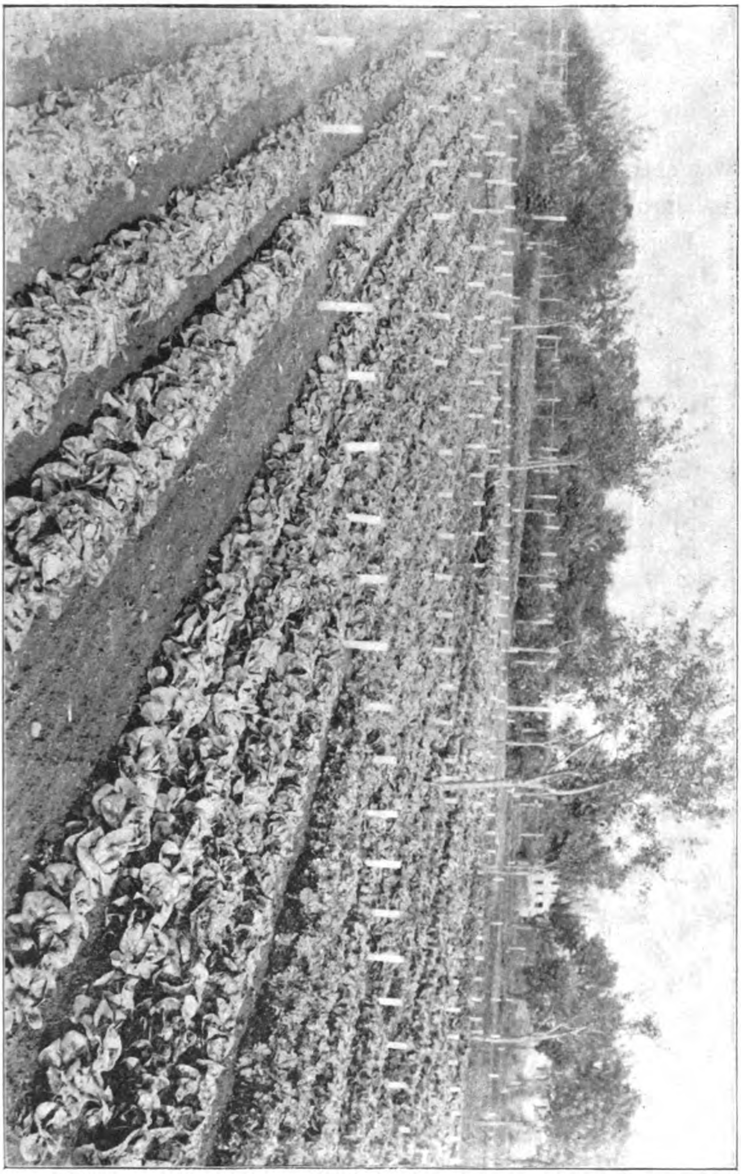

FIG. 9.—A part of the Experiment Station lettuce garden, 1897.

GARDEN LETTUCE, *LACTUCA SATIVA L.*

ANALYTICAL KEY TO THE VARIETIES.

Leaves entire near the apex, or rarely irregularly notched, and the edges angular and slightly wavy in outline.

- Leaves as long or longer than broad, but not twice as long as broad.
  - Leaves red, blotched or shaded with red.
    - Edges and exposed surfaces of leaves shaded with red, particularly after light frost.
      - Leaves glossy yellowish green, Nos. 1–5.
      - Leaves dull whitish green, Nos. 6–8.
    - Leaves green, or dull purplish green, with scattering blotches of dark red, or leaves dull purplish without red blotches.
      - Midrib green on under side, Nos. 9–14.
      - Midrib purplish on under side, Nos. 15–17.
    - Leaves dark red or heavily shaded with dark red.
      - Seeds black, Nos. 18–20.
      - Seeds yellow, No. 21.
  - Leaves green or yellowish green not shaded or blotched with red.
    - Edges of leaves without projecting points near the apex where the nerves terminate, or, if any, very minute.
      - Seeds white, Nos. 22–23.
      - Seeds black, Nos. 24–25.
    - Edges of leaves with projecting points where the nerves terminate near the apex.
      - Seeds white, Nos. 26–30.
      - Seeds black, Nos. 31–32.
      - Seeds yellow, No. 33.

Leaves not as long as broad, approaching reniform. Edges often notched and wavy, but not regularly dentate.

Seeds white, No. 34.

Seeds black, Nos. 35–36.

Leaves dentate near the apex and the edges usually gyrose,* or leaves at least twice as long as broad.

Leaves not twice as long as broad.

Leaves green or yellowish green, never reddish.

Leaves folding together and forming a firm head, Nos. 37–42.

Plants not forming a firm head.

Leaves of mature plants 8 inches or more high, Nos. 43-45.

Leaves forming a rosette close upon the ground, Nos. 46–49.

Leaves red or blotched or shaded with red.

Leaves folding together and forming a firm head.

Leaves bronze green, No. 50.

Leaves yellowish shaded with red, Nos. 51–55.

Leaves not forming a firm head, Nos. 56–59.

Leaves at least twice as long as broad, plants not forming a rosette upon the ground.

Leaves more or less shaded with red.

Edges of leaves gyrose near the apex, Nos.—

Edges of leaves smooth or without well defined teeth near the apex, Nos. 60–62.

Edges of leaves dentate near the apex, No. 63.

Leaves green, never reddish.

Leaves rounded at the apex.

Seeds white, Nos. 64–66.

Seeds black, Nos. 67–68.

Leaves tapering to a point at the apex, No. 69.

* Curled backward and forward in turns.

§ Leaves entire at the apex, or nearly so.

* Leaves as long or longer than broad, but not twice as long as broad.

+ Leaves red, blotched or shaded with red.

++ Edges of leaves shaded with red at least after frosts.

— Leaves yellowish, glossy green.

1. **White-Seeded Tennis Ball or Boston Market.**—Leaves glossy, yellowish green, usually more or less shaded with red, short and broad at the end. Edges smooth or dentate only towards the base, lamina irregularly folded between the nerves, midrib of the leaves forming the head flattened, lateral veins inconspicuous. Heads nearly spherical, often slightly open on top—inner leaves yellowish, weight, 4 to 6 ounces. Plant, 6 to 8 inches across with few spreading leaves at the base of the head. It is one of the earliest varieties to mature and for 25 years it has been the standard heading variety for forcing under glass. Larger kinds are now being planted in some houses. It heads quickly if planted in very rich soil in the open ground, but it soon goes to seed; for this reason the black-seeded Tennis Ball is preferred for garden culture.

FIG. 10.
White-Seeded Tennis Ball, or Boston Market, field grown. Plant 8 inches across.

FIG. 11.
Showing Plant of W. & B. Seeded Tennis Ball, grown from seed planted at the same time, the former with a blossom stalk a foot high when the head of the latter is mature.

2. **D'Alger.**—Leaves numerous, shaded with red, plants a little larger than the preceding variety but not forming as firm heads—seed, black. Obtained from France.

3. **St. Louis Black-Seeded Forcing.**—Leaves shaded with red, plants larger than the white-seeded Tennis Ball and mature one or two weeks later. Seed, black.

4. **Gros Cordon Rouge.**—Resembles D'Alger, seed, white. Obtained from France.

5. **Petit Cordon Rouge.**—Resembles No. 4, but smaller; seed, white. Obtained from France.

6. **Big Boston.**—Leaves green, or slightly shaded with red after frosts. Edges smooth near the apex, but dentate towards the base on the sides. Plants larger than the white-seeded Tennis Ball with more spreading leaves at the base of the head, otherwise resembling that variety. Another distinct variety, which appears to be identical with No. 7, is now frequently disseminated under the above name. The plants of this variety are a whiter shade of green, the leaves are not as broad at the end and their edges and surface appear slightly curly. The seeds of both this variety and No. 6 are white, and both kinds are grown by market gardeners under glass.

— — *Leaves dull or whitish green.*

7. **Trocadero.**—Leaves whitish green, longer than broad, edges usually shaded with red, margins slightly wavy, and the surface appearing a little curly. Seed, white. Obtained from France, where it is a popular variety for field culture and in market gardens.

8. **Belmont or Hot-house.**—Leaves dull, whitish green, appearing almost mealy when grown outdoors. Otherwise, the plants closely resemble the white-seeded Tennis Ball. This variety has been grown in forcing-houses, but is now less popular than other kinds.

++ ++ *Leaves blotched with red, or, in No. 16, leaves dull purplish green.*

— *Midrib green on under side.*

9. **California Cream Butter.**—Leaves glossy green, blotched with red and shaded with red at least after light frosts, thick,

elevations and depressions of the lamina, large and rounded, or those of the inner leaves pressed into folds, edges with conspicuous points on the sides and minute points where the veins terminate at the end. Plants large, 12 to 15 inches across, usually forming firm heads about four months after the seed is planted. A distinct variety, particularly good for private gardens. The leaves have a stronger flavor than those of the more delicate kinds, but to many tastes this is not objectionable, in fact, the leaves forming the heads are not, usually, excessively bitter. The vigorous constitution of the plants enables them to grow luxuriantly in soil that is not the best and in an atmosphere that is uncongenial. The form of the plant is like that of the white-seeded Tennis Ball, and the two varieties appear to be nearly related, although they are very distinct.

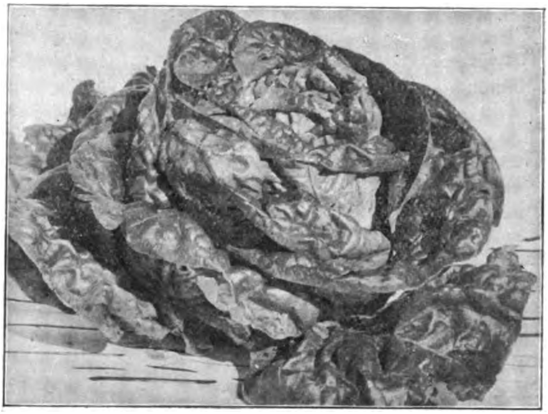

FIG. 12. California Cream Butter Lettuce. Plant 10 inches across.

10. **Winter Tremont.**—Leaves green, blotched and shaded with red, longer in proportion to their width than those of the California Cream Butter, and with less prominent points where the veins terminate at the ends of the leaves. Seed, white. Obtained from England.

11. **Standstead Park.**—Leaves green, blotched, and lightly shaded with red, but, like Winter Tremont, a less highly developed lettuce than the California Cream Butter, and apparently less desirable in this climate than that variety. Seed obtained from England.

12. **Philadelphia Butter Head.**—Leaves light green, rather long, blotched, and often shaded with red, surface very much crumpled and appearing curly, although the edges are but slightly undulating. Points distinct, but minute where the veins terminate at the end of the leaves. The inner leaves become yellowish when the heads mature, and this may account for the origin of the name, although it is not a peculiarity that is confined to this particular variety. Seed, white. A reliable kind for outdoor culture. Plants of medium size, usually forming good heads even in hot weather.

13. **Perpignan or Defiance Summer.**—Leaves yellowish green, blotched, and usually shaded with red. The leaves are longer in proportion to their width than those of the California Cream Butter, and less curly than those of the Philadelphia Butter Head. As now sold by seedsmen, it is an intermediate form between these two varieties. Seed, white.

14. **Passion or Madeira.**—Leaves green, shaded with brownish red, and blotched with dark red; a little crumpled, smooth at the margins, and with points only on the sides and towards the base. The color of the seed of this variety, as given by Vilmorin, is black, but that which we received, both from France and England, was white. It is considered one of the hardiest of all lettuces in France. It is generally used for winter culture in the open ground, but it is a less desirable summer lettuce than many other kinds which are of better quality and do not go to seed as quickly.

— — *Midrib purplish on under side.*

15. **Mogul** (*Brune Paresseuse* of the Fr.).—Leaves dull green, both blotched and shaded with red, considerably wrinkled, rather thick; points where the veins terminate at the ends of the leaves distinct, sides of the leaves dentate with larger points towards the base; under side of midrib, purplish. Heads nearly round, 5 or 6 inches in diameter, with numerous spreading leaves at the base. Seed, black. Obtained from France, where it is described

as hardy, exceedingly productive, and a very suitable kind for field culture, but this type of lettuce is not favorably received in American markets.

16. **Black-Seeded Brown Dutch.**—Leaves dull purplish green or heavily shaded, but not blotched with red, after frosts, surface with numerous folds and wrinkles between the nerves, points conspicuous at the ends of the leaves where the veins terminate; under side of midrib, purplish. Plants large and leafy, 12 to 15 inches across, heads spherical, generally loose, base leaves large and spreading. A very old variety that is still catalogued by seedsmen and grown in private gardens, although inferior to the more highly developed forms.

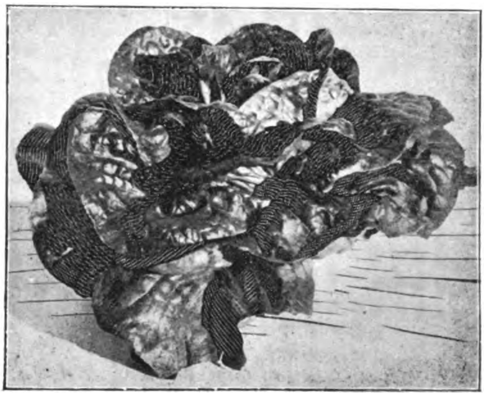

FIG. 13. B. S. Brown Dutch. Plant 10 inches across.

17. **Variegated or Spotted** (*Sanguine Panachee* of the Fr.).—Leaves blotched, streaked or shaded with red nearly all over, rather short and broad at the end, not dentate except near the base, laminæ of the outer leaves wrinkled, that of those forming the head folded and plaited, inner leaves of the head yellow but showing the red blotches. Plants 8 to 10 inches across, resembling in habit of growth the black seeded Tennis-Ball.

++ ++ *Leaves dark red or heavily shaded with dark red.*

= *Seed, black.*

18. **Red Bessen** (Marvel of Eng., *Rousse Bessen*, of Fr.).—Leaves bright and red, more brilliant than those of any other lettuce, rather thin and shiny, moderately crumpled, edges with minute points where the veins terminate at the ends of the leaves,

and with well defined points on the sides. Leaves narrow near the base. Plants 10 to 12 inches across, heads roundish, not very firm, inner leaves yellow, seed, black. A distinct variety, particularly interesting on account of the bright colored leaves, and very good when its table qualities are considered. The plants endure both heat and cold better than many other kinds, but it is not often planted.

FIG. 14. Red Bessen. Plant 10 inches across.

19. *Crisp as Ice.*—A sub-variety of the above. Leaves not as brilliant, plants smaller, heads usually firmer, seed, black. A very good summer variety, but, like the above, it is not often planted.

20. *Brown and Gold.*—A sub-variety of the Red Bessen, that has yellowish brown leaves. Seed, black.

— — *Seed, yellow.*

21. **Yellow-Seeded Brown Dutch** (*Rousse à Graine Jaune,* of the Fr.).—Leaves bronze green or nearly red after frosts, spreading, plants about 10 inches across, forming rather loose heads, the inner leaves of which are creamy white. Seed, yellow. This variety resembles Brown and Gold, but differs from it in having yellow instead of black seeds.

+ + *Leaves not shaded or blotched with red.*

— *Edges of leaves without projecting points near the apex.*

a. Seeds, white.

22. **Large White Summer.**—Leaves yellowish green, smooth at the ends or slightly notched, surface becoming crumpled and folded when the heads begin to form. Heads nearly round, 4 or 5 inches in diameter, and white. A popular kind for garden culture. The plants grow less rapidly than the black-seeded Tennis

Ball, and do not go to seed as quickly, but when the heads are mature they are hardly distinguishable from those of that variety. This type of lettuce is disseminated by seedsmen under the following names: Woods Cabbage, Philadelphia Cabbage, Standwell, Stubborn Head, Hubbards Market, Stonehead Golden Yellow, Thickhead Golden Yellow, Golden Stonehead, Golden Nugget and German Butterhead. Buttercup and Rudolph's Favorite are forms having yellow leaves.

23. **Blonde Royal.**—Leaves large, green, spreading, with the edges rolled inward in a characteristic manner, while the centres of the leaves bend outward. The under surface of the leaves is much lighter green than the upper, and where the leaves are rolled over they appear almost white. A very distinct variety, but apparently possessing little merit. Seed, white. Obtained from France.

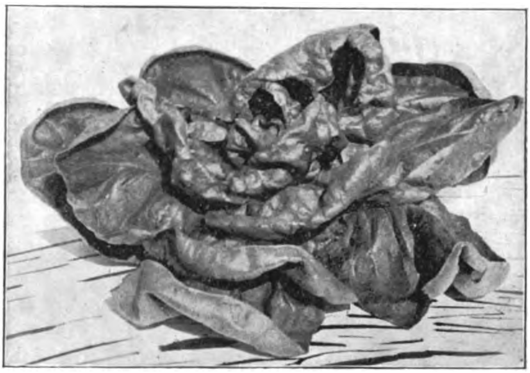

FIG. 15. Blonde Royal. Plant 12 inches across.

b. Seed, black.

24. **Black-Seeded Tennis Ball.**—Young plants a lighter shade of green than the white-seeded Tennis Ball. Leaves smooth at first, becoming very much crumpled and plaited after the heads begin to form. The heads are larger and looser than those of the white-seeded variety, and they mature about two weeks later. The leaves of this variety are rarely if ever shaded with red. The black-seeded Tennis Ball has been a favorite variety for many years. It is still extensively grown for markets, and is also one of the best kinds for private gardens.

The black-seeded All-the-Year-Round, and Frankfort Head, as

now sold by the seedsmen, too closely resemble the above to be considered distinct varieties, and the same is also true of Ninety

FIG 16. Black-Seeded Tennis Ball. Plant 10 inches across.

and Nine, Market Gardener's Private Stock, and Learned's black-seeded Tennis Ball.

25. **Black-Seeded Butter.**—Leaves green, considerably crumpled, and darker green than those of the preceding variety. The inner leaves of the heads are yellowish, or butter color, which might have suggested the name. A variable variety as now sold by seedsmen, and generally regarded as inferior to the black-seeded Tennis Ball. A large form of this variety has been named the Mammoth black-seeded Butter.

— — *Edges of leaves with minute projecting points near the apex.*

a. Seeds, white.

26. **White-Seeded-All-the-Year-Round** (*Blonde d' Etè* of the Fr.).—Leaves light green, a little crumpled and folded between the nerves, and the ends of the leaves often twisted to one side. Heads roundish, firm, weighing 4 to 8 ounces, formed by the leaves folding in together, but the outer one not usually overlapping at the ends. Plant closely resembling the large White Summer, but with the points at the end of the leaves where the veins terminate a little more prominent. We learn from good

authorities that this is a popular variety in both France and England. It is also grown in this country, but it is not considered as reliable a market variety here as the black-seeded Tennis Ball.

27. **Silver Ball.**—Leaves glossy green, edges with minute points near the apex. Plants about 10 inches across, heads compact, of medium size and light colored. A reliable variety. Seed, white.

28. **Chavigny White** (*Blonde de Chavigné* of the Fr.).—Leaves green, long and spreading flat upon the ground when the plants are young; edges with distinct points where the veins terminate; surface rather smooth with a few large folds and bunches; heads, nearly round, not very firm. Seed, white. Obtained from England and France. Plants of slow growth, slightly resembling the Deacon, but intermediate in appearance between this variety and the Large White Summer.

29. **Deacon** (*Impéreale* of the Fr.).—Leaves not glossy either above or below, leathery in texture, light yellowish green at first, but soon turning to a whiter shade, particularly the under surfaces, which are conspicuous when the plants begin to head. Edges of the leaves with distinct points where the veins terminate near the end, and with well-defined points towards the base. Plants of slow growth, spreading flat upon the ground when young, later forming large, loose heads, which remain in an edible condition for three or four weeks, even in hot weather, but the leaves are never very tender, and often they are noticeably bitter. An old variety, mainly grown in small gardens.

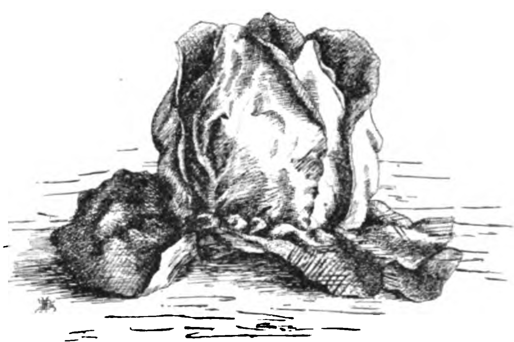

FIG. 17. Deacon. Plant 10 inches across.

30. **Hammersmith or Hardy Green Winter** (*Morine* of the Fr.).—Leaves green, usually light green, rather long, and narrow towards the base, edges with minute points where the veins terminate at the end, and dentate on the sides, surface moderately crumpled after the heads begin to form. Plants of slow growth, requiring four months or more after the seed is planted to mature heads. In appearance the plants resemble large White Summer, and, like it, this is an old kind, its cultivation in New England dating back certainly more than fifty years. Now it is rarely planted.

b. Seed, black.

31. **Fat Green Lettuce** (*Hative Verte Grosse* of the Fr.).—Leaves dark, glossy green, and very thick; edges with light colored points where veins terminate at the ends, and small teeth on the sides which increase in size towards the base; lamina raised irregularly, forming rounded ridges and bunches. Plants thick set, heading early; seed, black. A distinct variety, slightly resembling the thick-leaved spinach in appearance, although the leaves are less pointed and they soon begin to fold inward and form a head. Seed obtained from France.

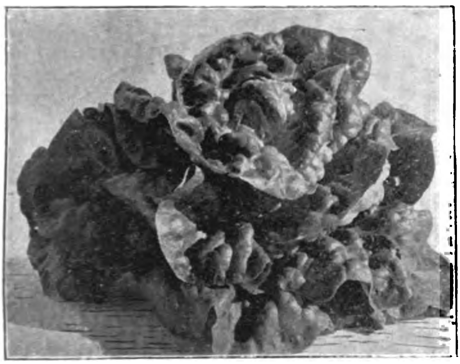

FIG. 18. Fat Green Lettuce. Plant 9 inches across.

32. **Turkish or Butter.**—Leaves light green, often silvery underneath, large and spreading, dentate on the sides and with prominent points at the ends. Surface of leaves wrinkled, veins conspicuous, lamina thick, head not very firm, seed, black. An old variety, now seldom planted.

c. Seed, yellow.

33. **Yellow-Seeded Butter.**—Leaves yellowish green, spread-

ing, requiring four months after the seed is planted to mature heads. In appearance the plants resemble the Large White Summer, but they are smaller; also they differ from the variety in having distinct hard points where the veins terminate at the ends of the leaves, also in having yellow instead of white seed. This variety is catalogued by seedsmen, but not generally planted.

** Leaves not as long as broad, approaching reniform, edges often notched, but not regularly dentate.*

— Seed, white.

34. **Golden Queen.**—Leaves short and broad, yellowish green, often shading to light yellow at the margins, edges smooth or with teeth only near the base, veins prominent, the lamina generally being depressed between them, at least when the plants are young. Base of midrib conspicuously shortened and thick, heads rounded, hard, weight 4 to 8 ounces, texture crisp, free from excessive bitterness, base leaves few and small, seed, white. A variety of unusual merit, either for field culture or forcing. The plants grow rapidly, and, when well cared for, they seldom fail to head. The heads average about the size, or a little smaller than, the white-seeded Tennis Ball, and, like that variety, the plants go to seed rather quickly when grown in the open ground. The Golden Queen is recommended for growing under glass, because it is thought to be less subject to disease than the Boston Market, but it is doubtful if, on the whole, it is equal to that variety for forcing.

FIG. 19. Golden Queen. Plant 8 inches across.

— — Seed, black.

35. **Black-Seeded Crisped** (*Crêpe à Graine Noire* of the Fr.).—Leaves green, very short and broad at the ends. When the

plants are young the leaves lie flat upon the ground, but the heads of this variety begin to form earlier than any kind that we have seen, so that the plants soon become ball-shaped, with few small base leaves. The heads mature quickly, but they are very small. This is the "*Petite Noire*" of the Paris market gardeners, by whom it is grown, because it thrives in a much closer atmosphere than the Tennis Ball can endure. The Golden Queen is a freer growing variety, but evidently it is nearly related to the *Petite Noire.*

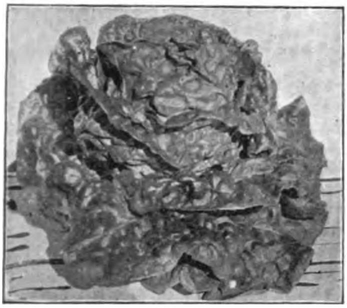

FIG. 20. B. S Crisped. Plant 6 inches across.

36. **Tom Thumb** (*Gotte Lente à Monter* of the Fr.).—A dwarf variety, more leafy than the *Petite Noire*, and the leaves a little longer in proportion to their width than those of that variety. Seed, black, a variable kind, as now sold by seedsmen, and of little merit.

§ 2. *Leaves dentate near the apex, and the edges usually gyrose or pinnatifid; or the leaves at least twice as long as broad.*

* *Leaves not twice as long as broad.*

+ *Leaves green or yellowish green, never reddish.*

++ *Leaves folding together and forming a head.*

37. **White Star.**—Leaves yellowish green, pale, or with only faint lustre, not serrate near the apex, margins slightly wavy, surface wrinkled and plaited along the midrib and towards the base; heads firm, slightly conical, weighing about 8 ounces; seed, white. An

FIG. 21. White Star. Plant 1 foot across.

American variety of recent introduction, and apparently having considerable merit.

38. **Hanson.**—Leaves yellowish green, glossy, when young, serrate, margins frilled and slightly puckered, general surface broad, with coarse elevations and depressions of the lamina along the midrib and towards the base. The inner leaves strongly incurved, often overlapping at the top of the heads one-quarter of their length, or more; heads large, weighing 8 to 12 ounces; seed, white. A standard variety for garden culture, and it is sometimes grown on a larger scale for market, but the smooth leaved kinds are preferred for that purpose. The Blonde Beauty and Blonde Blockhead are hardly distinct from it or from each other as the seed is now sold by seedsmen.

FIG. 22. Hanson. Plant 1 foot across.

39. **New York.**—Leaves dark green, particularly when the plants are young, otherwise very much like the Hanson, seed, white. A popular variety for outdoor culture but not equal in quality to the black-seeded Tennis Ball, which has flatter leaves with smaller midribs. A lettuce apparently identical with the above was obtained from France under the name *Chou de Naples*, and another from England named Neapolitan.

40. **Ice Drumhead or Malta.**—Leaves light green, tall and broad at the end; edges dentate or curled so as to appear dentate, surface nearly smooth, nerves prominent. Heads obovate, flattened at the top, loose. An old variety frequently mentioned by writers a century ago, but now rarely catalogued by seedsmen. Seed, white.

41. **Italian Ice.**—Leaves tall and nearly smooth, heads loose. Hardly distinct from the preceding.

42. **Denver Market.** — Leaves light yellowish green, glossy when young, serrate, margins full, with the points bending up and down and the edges inclined to curl inward towards the midrib. Head pointed, weighing about 6 ounces, plants of slow growth, seed, white. This variety differs from the Early Curled Silesian in having leaves that are less wrinkled and more curly at the edges, and also in forming firm heads, but on account of its slower growth and lack of crispness it is considered less desirable for garden culture than that variety. The Early Ohio of English seedsmen seems to be identical with the Denver Market.

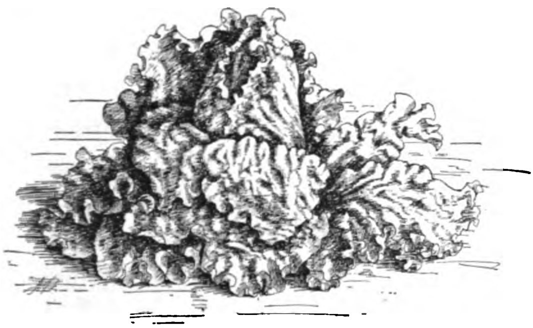

FIG. 23. Denver Market. Plant 1 foot across.

++++ *Plants not forming firm heads.*

— *Leaves of mature plants 8 inches or more high.*

43. **Early Curled Silesian or Simpson.**—Leaves yellowish green, rather long and narrow, the lower half more or less ascending but the ends bending downwards and often twisted to one side, surface very much wrinkled, the lamina generally raised above the nerves, edges finely dentate but not very curly, the curly appearance of the plants being

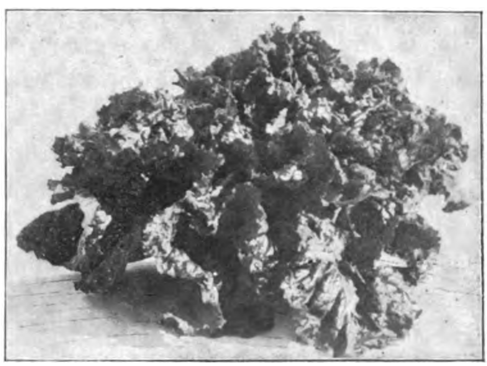

FIG. 24. Early Curled Silesian or Simpson. Plant 11 inches across.

mainly due to the wrinkled surface of the leaves, seed white. A very old variety but still one of the best for private gardens. It is easily grown, medium in quality, and it remains in condition for cutting several weeks before the blossom stalks appear. It does not bear transportation as well as the heading varieties and consequently it is not usually grown in market gardens.

44. **Black-Seeded Simpson.**—Leaves a peculiar whitish shade of green, spreading when the plants are young, but later rather tall and usually folding in toward the center, but not forming a true head; edges with rounded points and shallow furrows between them, often appearing nearly smooth. Surface but little crumpled, less so than the Early Curled Silesian. The plants are also taller than those of that variety, and the margins are not as finely dentate. So far as mildness of flavor and crispness of texture are concerned this variety is the standard of excellence, but the leaves wilt too quickly, and they are too bulky and brittle to make it a desirable kind for market. A well known variety, that is catalogued by all leading seedsmen.

Fig. 25. Black-Seeded Simpson.
Young plant 6 inches across.

45. **Grand Rapids.**—Leaves green, curled at the edges, and the sides twisting upwards and towards each other, in the widest part, in such a way that they appear more or less funnel-form. The surface of the leaves is but little crumpled, but the curly edges are prominent all over the plant. In this respect it resembles the Boston Curled, but in habit of growth it is intermediate between that variety and the black-seeded Simpson. Plant 8 to 12 inches across, not a heading variety. Seed, black. The Grand Rapids is extensively grown under glass for markets that do not require headed lettuce, but it is rarely seen in the forcing houses either about Providence or Boston.

—— *Leaves forming a rosette upon the ground.*

46. **Boston Curled.**—Leaves green, spreading out upon the ground; edges finely dentate, and the margin so curled and twisted that the points nearly or quite obscure the surface of the leaves. The plants form a rosette upon the ground, but do not head. Seed, black. Seldom planted, except for variety.

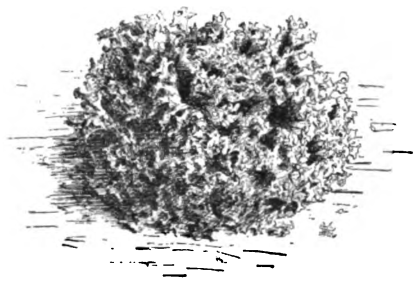

FIG. 26. Boston Curled. Plant 8 inches across.

47. **Endive-Leaved Lettuce** (*Chicorée à Couper* of the Fr.).—Leaves green, peculiarly cleft and incised nearly to the midrib, the lobes narrow, dentate on the edges, and curled at the ends. In appearance this variety resembles the Boston Curled, but the plants are scarcely one-half as large, and the leaves of that variety are only curled at the edges and not cleft. Seed black, very small, obtained from France. The leaves of this variety are especially good for garnishing meats, but not equal to those of larger kinds for salads. The plants are the first to go to seed.

48. **Green Fringed** (*Frisée de California* of the Fr.).—Leaves dull green, thick, and nearly smooth except at the margins, where much more lamina is developed than can spread out flat, and this is curled and frilled so that it forms points of irregular sizes and lengths which project in all directions, giving the leaves a fringed appearance. Plants of this variety have few leaves, which lie flat upon the ground. They bear the heat unusually well and send up blossom stalks later than most other kinds, but the leaves

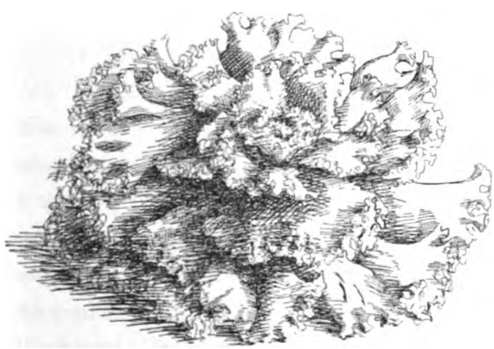

FIG. 27. Green Fringed Lettuce. Plant 10 inches across.

are never tender, and the variety has little to recommend it except its peculiar form. Seed, white.

49. **Oak-Leaved.** — Leaves light glossy green, irregularly lobed on the sides or pinnatifid and narrow towards the end, edges not dentate, and without projecting points where the veins terminate. Plants 12 inches across, leaves numerous, spreading out one above another in a dense mass but not forming heads. The leaves become more or less blanched, due to their crowded position, and remain in an edible state longer than those of heading kinds. They are also smaller and more conveniently served than those of the Early Curled Silesian, but hardly as crisp or free from bitterness. There is another form of the Oak-Leaved lettuce that has shorter leaves, which are lighter colored and truncated at the end, otherwise resembling the above.

FIG. 28. Oak-leaved Lettuce. Plant 1 foot across.

+ + *Leaves red, blotched or shaded with red.*

++ *Leaves folding together and forming a head.*

— *Leaves bronze green.*

50. **Mignonette.** — Leaves bronze green, curled and twisted edges, with minute stiff points and scattering small teeth, wavy and undulating, often turning inward, general surface considerably crumpled, under side of midrib green. Plants dwarf, 6 to 8 inches across, forming conical heads of unusual solidity. So tightly do the leaves fold together that few blossom stalks are formed unless the heads are cut open to allow them to push through. Seed, black. A distinct variety, unattractive in appearance but forming very solid heads, even in hot weather, which keep remarkably well after cutting.

—— *Leaves yellowish green, shaded with red.*

51. **White Silesian** (*Batavia Blonde* of the Fr.).—Leaves of the young plants yellowish green, edges shaded with red, finely dentate and a little curly. The leaves are broadly rounded at the ends and rather narrow towards the base, lamina sometimes raised

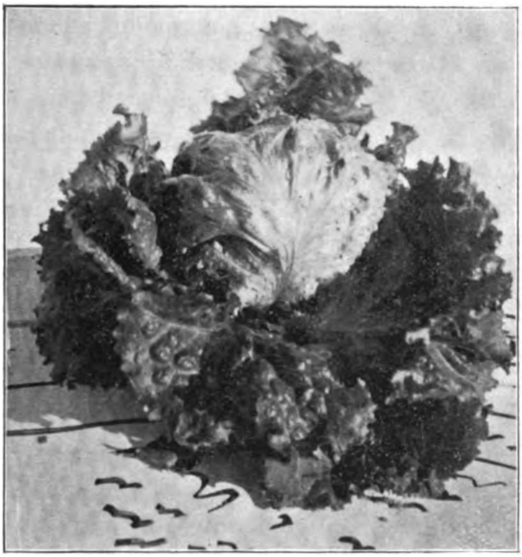

FIG. 29. White Silesian Lettuce. Plant 1 foot across.

above the nerves, but more frequently bending downward, the veins appearing embossed above it. Seed, white. A very old variety, now not as well known as the Iceberg, which is hardly distinguishable from it.

52. **Iceberg.**—Similar to the best forms of the White Silesian, which is an older name for the type. This is one of the best heading varieties of lettuce having leaves with dentate margins. The plants are 12 to 15 inches across, and form large light colored heads, which are rather firm but loose at the base; the leaves are also coarse and strongly curved, objections common to this type of lettuce. There is a lettuce known as Marblehead Mammoth, which is very much like the above, if not identical with it. Seed, white.

FIG. 80. Bossin Lettuce
Plant 10 inches across.

53. **Bossin.**—Leaves yellowish green, shaded with bright red, particularly along the nerves and on the edges, ascending, broad at the end, with prominent points which turn slightly forward; surface but little crumpled, heads loose at the base, surrounded by numerous spreading leaves. Seed, black, obtained from France.

54. **Bellegarde.**—Leaves brown nearly all over, plants resembling the Bossin, but smaller. Seed, black, obtained from France. Both this and the preceding are inferior varieties, and only grown in localities where the plants are allowed to remain in the field during the winter.

55. **Brown Batavian.**—Leaves dark dull green, shaded with brown, under side of midrib purplish, tall, broad at the end, edges puckered with projecting points where the veins terminate, and

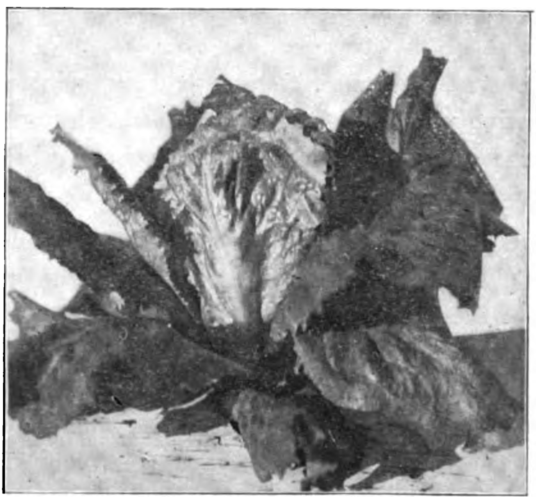

FIG. 81. Brown Batavian Lettuce. Plant 15 inches across.

deeply dentate on the sides. Texture of the leaves, thick, leathery, surface uneven; general appearance of the plants coarse. Seed, white, obtained from France.

++++ *Leaves not folding together and forming a head.*

56. **Prize Head.**—Leaves red or reddish both above and below, margins thickly beset with points, some of which turn up and others down; lamina much distorted with irregular elevations and depressions, general surface appearing curly and rounded up above the midrib, the end and sides of the leaves usually turning downward. Plants large and leafy, often two feet across, but not

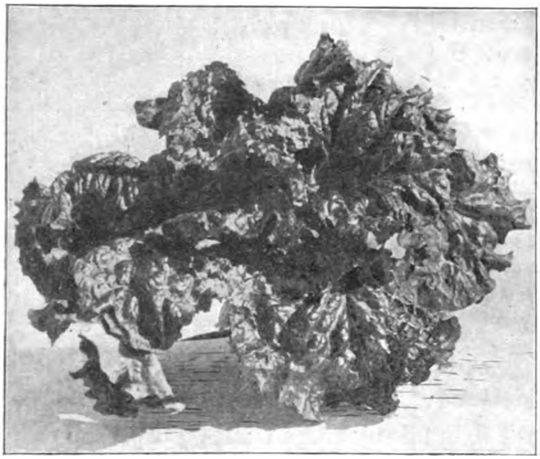

FIG. 32. Prize Head Lettuce. Plant 14 inches across.

forming heads. Seed, white. Apparently an American type, quite generally grown for family use. The plants are unusually vigorous and endure hot weather better, perhaps, than any other kind of equally good quality. They also do well in early spring and late fall.

57. **Tomhannock.**—Very closely resembling, and, perhaps, identical with No. 56.

58. **Onondaga.**—Smaller than No. 56 and the leaves a little more curly, otherwise like that variety. Seed, white.

59. **Chartier.**—Leaves reddish brown, edges dentate and slightly gyrose, not a heading variety. Hardly distinct from No. 56. Seed, white. The Chartier Pink is identical with the Chartier.

** *Leaves at least twice as long as broad, plants not forming a rosette upon the ground.*

+ *Leaves more or less shaded with red.*

++ *Edges of leaves gyrose near the apex.*

60. **Batavian Cos.**—Leaves green, slightly tinged with red, ascending with the ends bending downward, under side of midrib more or less purplish, edges curling regularly up and down, with small points at the end, but not distinctly dentate; lamina raised between the nerves, particularly in the centre of the leaves along the midvein, apparently an intermediate form between the Cos and cabbage lettuces. Seed, black, obtained from France.

FIG. 33. Batavian Cos Lettuce. Plant 9 inches across.

++++ *Edges of leaves smooth or without definite teeth near the apex.*

61. **Brown Geneva Cos** (*Romaine Brune de Geneve* of the Fr.). —Leaves greenish, faintly tinged with purple or red, rather narrow, growth nearly erect, edges smooth at the end of the leaves and with few points on the sides towards the base, midrib purplish on the under side; surface of the leaves very little crumpled and nearly flat. The plants grow rapidly and head naturally, but the heads are improved by tying. Seed, black, obtained from France.

62. **Red Winter Cos** (*Romaine Rouge d'Hiver* of the Fr.).—Leaves dark red on the upper side and reddish beneath, ascending or nearly erect, spatulate 12 to 16 inches long, 3 to 4 inches wide, and tapering slightly toward the apex, edge at end of leaf nearly smooth or at least not dentate, surface flat or spoon-shaped, or occasionally with the margins turned backward. Seed, black. The plants grow slowly but form moderately firm heads in cool

weather without tying. The leaves forming the heads have little red upon them.

++++++ *Edges of leaves dentate near the apex.*

63. **Bath or Brown Cos** (*Romaine Brune Anglaise* of the Fr.). —Leaves dull green, leathery, midrib purplish on the under side, edges conspicuously dentate near the apex, and the points turn upwards slightly; general surface of the leaves nearly smooth, growth upright or a little spreading, inner leaves forming a loose bunch in the centre. Seed, black. A coarse and inferior kind. There is another variety resembling the above, but having white seeds, which is known as the white-seeded Brown Cos. The *Chicon Palatine* of the French differs from the Brown Cos in having greener leaves, which are blotched as well as shaded with red, and the edges of the leaves are less distinctly dentate at the end, there is also less purple on the under side of the midrib. Seed, black, obtained from France.

FIG. 34. Bath or Brown Cos Lettuce. Plant 15 inches across.

+-+- *Leaves green, never reddish.*

++ *Leaves rounded at the apex.*

— *Seed, white.*

64. **Paris White Cos** (*Romaine Blonde Maraîchère* of the Fr.). —Leaves green, ascending, broadly spatulate, 12 to 15 inches high, 3 to 5 inches wide, margins smooth or slightly wavy near the apex, projecting points or lobes numerous on the sides, particularly near the base. Surface of the outer leaves a little raised between the larger nerves, surface of the inner leaves considerably folded. The heads are 8 to 12 inches high, rounded at the ends,

firm, and weigh from 12 to 24 ounces each. In quality this variety is hardly surpassed by any kind of lettuce. It is customary to tie the leaves together when the heads are forming, although when the plants are well grown this is not always necessary. The Paris White Cos is grown all over the world and represents perhaps the

FIG. 85. Paris White Cos Lettuce.
Plant 12 inches across.

highest type of the Cos lettuce. Other varieties closely resembling the above, and which appear to be hardly distinct from it, are the Trianon Cos and the Paris Self-folding Cos. The White Heart and Dwarf White Heart, if distinct varieties, differ but little from the Paris White Cos and are inferior to it.

65. **Paris Green Cos** (*Romaine Verte Maraîchère* of the Fr.).—Leaves a little deeper green than those of the Paris White Cos, and the plant not quite as large but maturing a few days earlier. Otherwise like the Paris White Cos. Seed, white.

66. **Hardy Winter Cos.**—Leaves green, 8 to 10 inches long,

margins dentate near the apex, surface a little rough, texture of the leaves leathery. Seed, white, obtained from England.

—— *Seed, black.*

67. **Balloon Cos.**—Leaves light green, nearly upright, 10 to 12 inches long and 3 to 4 inches wide; margins uneven near the apex, but not regularly dentate, sides with projecting teeth or lobes. Surface a little crumpled, midrib and larger nerves translucent. Plants leafy and the heads not very firm even when tied. Seed, black, obtained from England and France. Another variety with lighter colored and a little narrower leaves, but resembling the above otherwise, was obtained from France under the name *Romaine Blonde sans Pareille.*

68. **Ground Cos** (*Romaine Pomme en Terre* of the Fr.).—Leaves dark, glossy green, 6 to 8 inches high and 1½ to 2 inches wide, a little crumpled on either side of the midrib, which is fleshy and slightly translucent, edges smooth near the apex and the points, if any on the sides with rounded ends. A dwarf variety slightly resembling the next but intermediate between it and the Paris White Cos. On very rich soil it forms small heads close to the surface of the ground. Seed, black.

FIG. 36.
Ground Cos Lettuce.
Plant 6 inches across.

++++ *Leaves pointed at the apex.*

69. **Asparagus Cos.**—Leaves bright green above, dull beneath, 1 foot or more long, 1 to 2 inches wide in the middle, tapering to a point at the end and becoming narrow towards the base; edges smooth near the apex and more or less dentate on the sides; surface smooth, growth upright, not a heading variety, blossom stalk 4 feet high. Although very distinct in appearance this seems to be only an unimproved form of *Lactuca sativa* without specific peculiarities in the inflorescence, yet it has been described as *Lactuca angustana.* There is another form of the Asparagus Cos with reddish stems and bronze leaves that is less common than the above.

FIG. 37. Asparagus Cos Lettuce.
Plant 20 inches across.

As a garden esculent the Asparagus Cos lettuce has little value, although the fleshy midribs are tender, juicy and peculiarly pleasing to the taste if gathered just before the blossom stalks show in the centre of the plants.

THE ASPARAGUS RUST.

Notes on Its Recent Outbreak at Concord, Mass., and in the Rhode Island Market Gardens.

L. F. KINNEY.

Until the summer of 1896 asparagus seems to have been free from all diseases regarded as serious by commercial growers. During that season the rust was noticed in various places, but it did not become alarmingly prevalent in the New England States until the latter part of the past summer, 1897.

It was about the middle of August that a communication was received from Mr. C. W. Prescott, one of the largest asparagus growers in the vicinity of Concord, Mass., stating that the rust was spreading rapidly in that locality and that large interests were threatened by it.* Soon after this we visited Concord, and, in company with Mr. Prescott, drove about among the principal asparagus farms in the vicinity. The pernicious effects of the disease were evident everywhere. Some fields had been mowed over and the stalks burned, other fields were leafless and the stalks apparently lifeless, but the most of them were just beginning to turn brown. The owners were, without exception, exceedingly concerned about the condition of their fields, and they all agreed that they had never seen anything like it before.

Up to this time the disease had not been reported by asparagus

* The aggregate area of the asparagus beds about Concord has been estimated to be 350 acres.

growers in this State, but an investigation showed that its presence here had been overlooked.

By the first of September all of the large asparagus beds in the vicinity of Auburn were considerably brown. This was fully a month earlier than the stalks should have ripened naturally. It did not require a microscopic examination to discover the trouble: the snuff-like germs of the disease were bursting from the stalks, branches and leaves, and in some cases the leaves were actually covered with them. Generally the rust spots were thickest near the top end, the leaves dropped from the upper branches first. Occasionally a branch near the ground escaped the disease and remained fresh and green after all above it was leafless.

We also noticed that stalks from which every leaf had fallen often sent out new branches from the lower joints, and that these branches made considerable growth late in the fall, which was but slightly attacked by the rust. This, it seems to us, is additional evidence in support of the opinion entertained by Mr. Prescott, viz.: that it is a mistake to mow off the stalks while they remain full of sap, even if they appear to be dead externally.

The effect of the disease upon the plants is to exhaust their vitality, both by the destruction of the assimilating cells and much of the assimilated matter. To cut the stalks off entirely in the middle of the growing season only makes worse a matter which is already bad enough. When Canada thistles are treated in this way it is expected that it will kill the roots. It sometimes fails to do so, and this may be the case with asparagus; nevertheless it is unnecessarily harsh treatment.

It was thought by some that mowing and burning the stalks would stop the asparagus rust from spreading, but the folly of this supposition soon became evident at Concord. Before the growers were aware of it the disease had become epidemic, and at the time of our visit, about the first of September, not a field could be found in the vicinity in which the disease was not present. The fact that the disease was discovered simultaneously in all of the large asparagus fields about Auburn is further proof that at-

tempts to suppress the disease by the destruction of the growth on a single field must prove futile.

Concerning the distribution of the asparagus rust (fungus*) so far as actual records have been made, Dr. B. D. Halsted, of New Jersey, wrote us, under date of December 20th, as follows:

"In 1896 it seemed to be limited to New England, Long Island, New Jersey, Delaware and Maryland."

"During 1897 the disease has been worse than last year, and the area infested has extended to include the large asparagus fields in South Carolina."

In Rhode Island, while no noticeable damage has occurred from it except in the vicinity of Auburn, it is disseminated throughout the State. Specimens of diseased stalks from "Paradise Farm," East Greenwich, were forwarded to us by Hon. H. A. Rhodes. We have also received similar specimens from Portsmouth, and have ourselves noticed the disease in several places in southern Rhode Island. It was not discovered in the immediate vicinity of Kingston until late in the fall.

Thus far all efforts to control the asparagus rust have been only partially successful, and at present no remedy for it is known. It is probable that the Bordeaux mixture would be effectual if enough of it could be applied, but it is doubtful if its use, at least in the manner approved for potato fields, is practicable.

In the first place asparagus is very smooth, and substances do not readily adhere either to the leaves or stalks, and, secondly, there is so much growth upon the fields and it is so dense that it seems to us that the cost of spraying, if the work was done several times, and thoroughly, would, in itself, be prohibitory. It is possible, however, that beds of seedling plants can be sprayed to advantage, and that the Bordeaux mixture can be profitably used upon old beds for a month or more after the close of the cutting season. Investigations have often shown that plant diseases can be controlled better by avoiding conditions that are favorable to them than by

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* *Puccinia asparagi* D. C.

applying remedies. So at first we were led to inquire if this was the case with the asparagus rust. A large number of fields were examined and the soil and atmospheric conditions considered. So far as observed, the character of the land, the kind of fertilizer used, the method of cultivation practiced, and the slight variation in humidity of the air in different parts of the infested areas in Massachusetts and Rhode Island, have not had any noticeable influence upon the development of the disease.

There may, however, be some difference in the susceptibility of different varieties to the disease. At least three cases have come to our notice which appear to indicate this—one was in West Acton, Mass., one in Concord, Mass., and one in Auburn, R. I.

The difference in the amount of rust found on plants of different kinds may not have been due to varietal peculiarities but from the limited data accessible it at least appeared to be. The kinds least injured by it were the Palmetto and an unnamed variety imported from France several years ago.

For some reason plants of these kinds, growing beside the Moore's cross-breed, were but slightly affected, while the latter was badly rusted.

How much value should be placed on this apparent difference in varieties is uncertain at the present time, yet it is, probably, a matter worthy of some attention.

Shallow plowing of the beds, after the stalks have been cut and burned, is being tried in Concord. It is thought that possibly in this way the germs of the disease, which are lying about on the surface of the ground, can be covered up and destroyed.

Whether the rust extends down the asparagus stalks to the roots or not is yet an open question, but we expect that it does not. Still the characteristic rust spots often occur on the butts even below the surface of the ground, and, as more or less of these adhere to the roots, even after the spring cultivation, it is probable that they will be a fertile source of infection for the next season's growth.

This can, perhaps, be remedied by digging out and burning

them early in the spring when the beds are worked, and before the disease germs become active.

The importance of being able to control the asparagus rust is more apparent than is often the case with plant diseases, first, because the destructiveness of the disease is evident, and second, because it is known that asparagus beds are valuable. An acre of asparagus, in a high state of cultivation, represents an investment of from \$500 to \$800. The aggregate value of the asparagus beds, in the two asparagus growing centres referred to, is, at least, \$200,000.

Should this disease continue its destructive course a few years longer with as much virulence as was shown last season, particularly in the central part of Concord, the cultivation of asparagus must be abandoned, and a large part of the capital that has been put into the work will be lost.

While it is hardly probable that the disease will entirely kill out the asparagus plants, at the present time it can only be a matter of conjecture just what effect it will have upon them and upon the business of growing asparagus for market.

AGRICULTURAL DIVISION.

CULTURAL EXPERIMENT WITH POTATOES.

CHAS. O. FLAGG, G. M. TUCKER AND J. A. TILLINGHAST.

Early in 1896 an experiment was planned for the purpose of comparing the growth and product of potatoes upon land prepared more or less deeply for planting, and thereafter more or less thoroughly cultivated. The experiment also included the planting of sets at different distances apart. The experiment was repeated in 1897, and for convenience, and to better summarize the results, the work will be discussed under the three following heads:

1st. The comparative yield of potatoes upon land spaded at depths varying from 4 to 18 inches.

2nd. The effect of very thorough and less thorough cultivation upon the yield of potatoes.

3rd. The effect of planting sets at greater or less distances, as shown in the yield of potatoes.

PLOT 16.

The land selected for the experiment was one of our permanent plots, and designated as number 16. The soil is a sandy loam underlaid by two or three feet in thickness of yellow loam, beneath which is an open gravel extending below the water-table, which here is from eighteen to twenty feet below the surface. This plot

was a portion of an exhausted meadow, producing only a small quantity of fine hay in 1889*. That year, after the hay was removed, the field was plowed about 6 inches deep, fertilized with a light dressing of ground bone, and sown with Hungarian millet. The season being dry only a partial crop resulted. The following spring a dressing of about six cords per acre of stable manure (from horses) was applied broadcast, the ground plowed, harrowed, and again sown to Hungarian, and a moderate crop was harvested. In 1891 the field was laid out into permanent plots and planted to beans, without manure. In 1892[1] all the plots were planted to Rhode Island White Capped Flint corn, without manure or fertilizer of any kind, to further determine the natural fertility and relative crop producing capacity of the various plots. The yield upon plot 16 was 410 lbs. of corn and stover, weighed when cut. After husking there were 85 lbs. of stover, 71.5 lbs. of hard corn on the cob, and 51 lbs. of soft corn on the cob. This yield was at the rate of 637 lbs. of stover and 7.4 bushels of hard corn per acre, showing that the soil, in spite of the fertilizer and manure applied in 1889 and 1890, was very much exhausted.

In 1893 this plot received a dressing of fertilizer composed of the following named materials, and the weights given were used per acre: dissolved bone, 240 lbs.; tankage, 300 lbs.: muriate of potash, 120 lbs.; and slag meal, 300 lbs. The soil was well prepared to make a fine seed bed, and the plot sown to alfalfa[2]. A moderate growth was secured during the season, and the ground mulched in the early winter with seaweed at the rate of 8 cords per acre to protect the alfalfa. Most of the plants winter-killed, and the plot was plowed and reseeded to alfalfa in 1895, *without*, however, any application of air-slacked lime, and only a scattering growth, incapable of withstanding the winter, resulted. As the alfalfa was sown broadcast, weeds, and especially sorrel, gained possession to a considerable degree, and partially covered

* See Fourth Annual Rpt. R. I. Agl. Expt. Sta., page 14.

[1] See Fifth Annual Rept R. I. Agl. Expt. Sta., page 188.

[2] See Seventh Annual Rept. R. I. Agl. Expt. Sta., page 190.

the ground in the spring of 1896, when the cultural experiment with potatoes was begun.

SPADING DIFFERENT DEPTHS.

FIRST YEAR, 1896.

Plot 16, like all the permanent plots, is 30 feet wide and 193.6 feet long. For this experiment it was divided into 16 equal sections, each 12.1x30 feet in area, and numbered 1–16, beginning at the north end. The first ten plots were devoted to different depths of preparation of the soil and more or less thorough cultivation, while the six remaining plots, at the south end, were used in planting potato sets at different distances.

Sections 1 and 2, at the north end, were carefully spaded only 4 inches deep. Care was taken to bury the growth on the surface and have the inverted soil as level and mellow as possible with such shallow spading.

Sections 3 and 4 were spaded 8 inches deep, the same care being exercised to bury the surface growth and have the earth finely divided at the top.

Sections 5 and 6 were spaded 12 inches deep, but the whole soil to that depth was not inverted. Care was taken not to bring the subsoil to the surface. Only the agricultural soil, in this case about seven inches deep, was inverted, while the remaining five inches of subsoil were simply dug up and made mellow but left at the bottom.

Sections 7 and 8 were spaded 15 inches deep, in the same manner as sections 5 and 6—the subsoil being left at the bottom.

Sections 9 and 10 were spaded 18 inches deep, in the same careful manner.

Sections 11 to 16, inclusive, were spaded 12 inches deep and devoted to the trial of seed tubers, planted at different distances. The spading was done April 27 to 30th, and, on May 2d, the whole plot was thoroughly harrowed with a cutaway harrow, and a fertilizer, at the rate of 1,815 lbs. per acre, applied broadcast. The

fertilizer was made up from the following materials: Nitrate of soda, 105 lbs.; tankage, 750 lbs.; dissolved phosphate rock, 540 lbs.; fine ground bone, 120 lbs.; and muriate of potash, 300 lbs. In order to guard against variations due to the influence of outside rows, and secure practical field conditions, a row of potatoes was planted on the line dividing each two sections. At the end of the season this row was dug and discarded from the experiment. There was just sufficient space on each section, after planting the division line rows, to plant 3 rows, thirty-six inches apart, and the furrows were made four inches deep by hand. "Queen" potatoes were selected for planting from stock grown in the vicinity, and tubers, averaging about three to four ounces in weight, were used. The sets were placed twelve inches apart in the row, making 30 sets per row, and 90 sets per plot. The same weight of seed tubers, 6.45 lbs., was used for each section, and it was, in each case, divided evenly into 90 sets, giving an average weight of 1.15 ounces per set. The planting was done on May 2d, and the seed was covered by hand about four inches deep.

May 19th a smoothing harrow was used on the plot to stir the surface, and May 20th and 22d the soil was stirred with a Breed's weeder, to kill any sprouting weed seeds. The potatoes at this time were breaking the ground, and, on the 28th of May, quite a number of potato beetles were found and picked off by hand. It will be observed that, in sections 1–10, inclusive, which are now briefly considered, two sections were laid out upon each different depth of spading, with the purpose in view of giving one section sufficient cultivation to keep down all weed growth, and an extra amount to the other. This extra cultivation consisted mainly in deeper and more thorough working with the hand cultivator, going twice in a row, and working deeper on the odd numbered or thorough cultivation sections than upon the even numbered sections. Sections 1, 3, 5, 7 and 9, only, were cultivated on May 29th. All the sections were cultivated by hand on the following dates, the odd numbered rows deeper and more thoroughly, as stated above: June 1st, 12th, 16th and 19th, and on the 20th the

potatoes were hoed. They were again cultivated on the 29th and hoed on the 30th. Paris green was applied with a powder duster on June 26th, and on July 4th and 14th. The potato blight appearing, the plot was sprayed with Bordeaux mixture on July 23d, 28th and 31st. What few weeds had lived through the various cultivations were pulled out on August 21st.

The potatoes were dug September 28th, assorted, weighed and counted. In assorting, all tubers over two ounces in weight were classed as large. It must be borne in mind that each different depth of spading included two sections, one more and one less thoroughly cultivated, but as the relative treatment was the same for all the depths of spading, the joint yield of the two sections upon the same depth of spading can be compared with the joint yield of any other two sections. The yields are from the space occupied by three rows in each section or 270 square feet of area, or for each depth of spading, 2 sections equalled 540 square feet, and from this area the acre yields are calculated. Table I gives the joint yields of each two sections in bold faced type to facilitate comparison.

By comparing the figures printed in bold type it will be noticed that the difference in yield between the plot spaded 4 inches deep and that spaded 8 inches deep is slight, and that both exceed that of the next plot, spaded 12 inches deep, while all three are exceeded by the yields upon the plots spaded 15 inches and 18 inches deep, the last named giving the greatest yield both of total crop and large tubers.

TABLE I.

Showing the Weights and Numbers of Potato Tubers grown upon Plots Spaded to Different Depths in 1896.

		Weight in Pounds.			Number.		
		Total.	Large.	Small.	Total.	Large.	Small.
Spaded 4 inches deep.	Sec. 1..	119.75	81.25	38.50	620	261	359
	Sec. 2..	124.00	80.50	43.50	656	257	399
Total..................		**243.75**	**161.75**	**82.00**	**1,276**	**518**	**758**
Spaded 8 inches deep.	Sec. 3..	132.00	88.00	44.00	653	277	376
	Sec. 4..	118.00	75.75	42.25	607	249	358
Total..................		**250.00**	**163.75**	**86.25**	**1,260**	**526**	**734**
Spaded 12 inches deep.	Sec. 5..	117.25	76.25	41.00	587	236	351
	Sec. 6..	119.00	78.00	41.00	594	243	351
Total..................		**236.25**	**154.25**	**82.00**	**1,181**	**479**	**702**
Spaded 15 inches deep.	Sec. 7..	121.75	80.50	41.25	602	250	352
	Sec. 8..	127.50	89.00	38.50	619	294	325
Total..................		**249.25**	**169.50**	**79.75**	**1,221**	**544**	**677**
Spaded 18 inches deep.	Sec. 9..	125.00	79.50	45.50	630	266	364
	Sec. 10.	133.25	92.75	40.50	656	300	356
Total..................		**258.25**	**172.25**	**86.00**	**1,286**	**566**	**720**

SECOND YEAR, 1897.

The same division lines were maintained on plot 16 as were laid out in 1896, and the same areas spaded on April 26th, to the depths of 4, 8, 12, 15 and 18 inches respectively. On April 30th the plot was well harrowed and the same weight of fertilizer, 1,815 pounds, compounded after the formula which was used the previous year, was applied broadcast, and the ground levelled with a Breed's weeder. The fertilizer used contained 3.23 per cent. of nitrogen, 7.91 per cent. of available phosphoric acid, and 8.37 per cent. of potash. "Queen" potatoes were again planted. The rows were laid out as before, and the product from the division line row was discarded from the calculations. A little more seed was used than in 1896, as 9 pounds of seed tubers were cut into 90 pieces, giving an average of 1.6 ounces per set. The drills were laid out with a line, opened by hand four inches deep, and the sets dropped exactly 12 inches apart—an engineer's chain with foot links being laid in the drill to insure accuracy. The planting was done April 30th. The sets were covered by hand 4 inches deep. On May 5th, 17th and 22nd, Breed's weeder was used over the whole plot. June 5th a hand wheel cultivator was used, working deeper and more thoroughly on the odd numbered sections than upon those with even numbers, which practice was continued through the season. June 8th the odd numbered sections only were hand cultivated. On the 10th and 16th all were hand cultivated, and hoed on the 18th. The 22nd the odd numbered sections alone were cultivated, and on July 3rd all were hoed and a little earth drawn about the vines. Paris green was applied with a powder gun June 17th, and again on July 8th. July 3rd the vines were sprayed with Bordeaux mixture and Paris green. The vines were sprayed with Bordeaux mixture alone on July 15th, 19th, 24th August 3rd and 9th. The repeated sprayings were made necessary by the severity of the blight and the frequent rains which washed the mixture off the vines. September 27th the crop was dug, assorted, weighed and counted. All tubers 2 ounces or more in weight were classed as large.

TABLE II.

Showing the Weights and Numbers of Potato Tubers grown upon Plots Spaded to Different Depths in 1897.

		WEIGHT IN POUNDS.			NUMBER.		
		Total.	Large.	Small.	Total.	Large.	Small.
Spaded 4 inches deep.	Sec. 1..	90.25	39.0	51.25	1,060	218	842
	Sec. 2.	95.00	48.0	47.00	1,059	280	779
Total.....................		**185.25**	**87.0**	**98.25**	**2,119**	**498**	**1,621**
Spaded 8 inches deep.	Sec. 3..	97.0	55.0	42.0	920	311	609
	Sec. 4..	96.0	61.0	35.0	911	343	568
Total.....................		**193.0**	**116.0**	**77.0**	**1,831**	**654**	**1,177**
Spaded 12 inches deep.	Sec. 5..	96.5	59.0	37.5	893	318	575
	Sec. 6..	93.0	57.0	36.0	779	297	482
Total.....................		**189.5**	**116.0**	**73.5**	**1,672**	**615**	**1,057**
Spaded 15 inches deep.	Sec. 7..	87.0	55.5	31.5	780	314	466
	Sec. 8..	95.0	54.0	41.0	950	302	648
Total.....................		**182.0**	**109.5**	**72.5**	**1,730**	**616**	**1,114**
Spaded 18 inches deep.	Sec. 9..	92.0	51.5	40.5	903	285	618
	Sec. 10.	96.0	55.0	41.0	897	318	579
Total.....................		**188.0**	**106.5**	**81.5**	**1,800**	**603**	**1,197**

The total yield of tubers was quite uniform on all the sections, the lowest weight being 182 pounds on the 15 inch spading, and the highest 193 pounds on the section spaded 8 inches deep. In the yield of marketable tubers, however, there was more difference, as the lowest yield was 87 pounds on the 4 inch spading, and the highest on the 8 and 12 inch spading, where the weight was 116 pounds in each case. We have calculated the weights in tables I and II into yields per acre in bushels, and present the results in table III.

TABLE III.

Showing the Yields of Potatoes in Bushels per Acre from Plots Spaded to Different Depths in 1896 and 1897.

	Year.	Bushels Per Acre.		
		Total.	Large.	Small.
Spaded 4 inches deep	1896	327.70	200.79	126.91
	1897	249.06	116.93	132.13
Average	.....	**288.38**	**158.85**	**129.52**
Spaded 8 inches deep	1896	335.78	220.15	115.63
	1897	259.48	153.26	106.22
Average	......	**297.63**	**186.70**	**110.92**
Spaded 12 inches deep	1896	317.62	207.38	110.24
	1897	254.77	153.26	102.51
Average	......	**286.34**	**180.32**	**106.37**
Spaded 15 inches deep	1896	335.10	227.90	107.20
	1997	244.68	147.21	97.47
Average	......	**289.89**	**187.55**	**102.33**
Spaded 18 inches deep	1896	347.20	231.51	115.69
	1897	253.25	143.18	110.07
Average	......	**300.22**	**187.34**	**112.88**

Taking an average of the crops for the two years we find that there is comparatively little variation in the total yield, as the difference between the lowest average yield on the plot spaded 12 inches deep, and the highest average on the plot spaded 18 inches, is but 13.88 bushels per acre. The second best average total crop was produced on the 8 inch spading, and was only 2.59 bushels per acre less than the best yield. We find a much greater difference in the yields of marketable tubers, which portion is always the measure of the value of the crop. The smallest yield is on the 4 inch spading, and the largest yield upon the 15 inch spading, but the latter only exceeds the yield of large tubers on the 18 inch spading by .21 of a bushel per acre, and the yield of the 8 inch spading by .85 of a bushel. The difference in the yield of large tubers between the 4 inch spading and the 8 inch depth is 27.85 bushels per acre, but the difference of total yield is only 9.25 bushels, hence the 4 inch spading exceeds the 8 inch in quantity of small potatoes produced. The percentage of small tubers in the total yield is much larger in all cases than it should be in a profitable crop. In the case of the plot spaded 4 inches deep, 44.91 per cent. of the crop was small, *i. e.*, two ounces or less in weight, and 55.09 per cent. was large, while in the case of the 8 inch spading there was 37.26 per cent. of small tubers, and 62.74 per cent. of large ones. The lowest percentage of small ones was upon the plot spaded 15 inches deep, and was 35.29 per cent. The proportion of small ones was greater in 1897 than in 1896, which is doubtless largely due to the severity of the blight and the frequent rains, which washed off the Bordeaux mixture so that even the frequent sprayings did not prevent the blight. Another reason may be the acidity of the soil, as our chemist has shown[1] that there is a gain of about 10 per cent. in large tubers through the use of air-slaked lime upon acid soils. Great care must, however, be exercised, that the germ of scab fungus is not introduced on the seed tubers. The use of lime creates neutral or alkaline conditions in

[1] Bulletin No. 88, pp. 48, 50 and 79.

the soil which are very favorable to the propagation of the scab fungus, and a badly scabbed crop might result. Treating the seed tubers with formalin or corrosive sublimate[1] will practically kill the germs, so that, unless the soil is already infected, a crop generally free from scab can be secured, even though lime be used. Lime also has a tendency toward hastening the ripening of the crop, and might prove of some advantage in that respect when early potatoes are grown. In planting each section the same weight of seed tubers was used in each case, and divided into the same number of sets as nearly as possible of equal size. In 1896 seed tubers at the rate of 20.8 bushels per acre were used, and in 1897 the seeding was a trifle heavier, or at the rate of 24 bushels per acre. Too heavy seeding is known to increase the percentage of small potatoes as compared with the large, although the total yield is usually increased as compared with lighter seeding.

THE EFFECT OF MORE AND LESS THOROUGH CULTIVATION.

In the account of the previous experiment, regarding the effect of preparing the ground to different depths for planting potatoes, it has been stated that upon each area spaded to a given depth two sections were laid out, hence the experiment included 10 sections, and of these all the *odd* numbered sections were given *more* thorough cultivation and the *even* numbered sections *less* cultivation during the growing season. This arrangement placed one more and one less thoroughly cultivated section upon each different depth of spading, and we will now consider the effect upon the crop of the difference in cultivation.

FIRST YEAR, 1896.

The reader is referred to pages 324 and 325 for the details relating to the preparation of the ground, fertilization and planting of the

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[1] Bulletin No. 46, R. I. Agl. Expt. Sta., pp. 92 and 94.

crop. The only horse cultivation of the sections was in the use of the smoothing harrow on May 19th and Breed's weeder on the 20th and 22d, when the potatoes were about breaking ground, and was given, of course, to all sections alike. The after cultivation was done with a good hand wheel cultivator, used by one or two men, which insured against accident in horse cultivation and the tramping of a horse on adjoining plots. The hand cultivator, when used by one man, stirs the soil quite thoroughly about two inches deep, which was the extent of the cultivation on the *even* numbered sections. In the case of the *odd* numbered sections, besides more frequent cultivation it was always deeper and more thorough. The hand cultivator was adjusted to work about four inches deep, instead of two, and the help of an extra man was required to use it.

Sections 1, 3, 5, 7 and 9, were planted May 2d, harrowed May 19th, Breed's weeder used May 20th and 22d, hand cultivator used May 29th, June 1st, 12th, 16th and 19th, hoed June 20th, cultivated June 29th, and hoed the 30th. This made a total of 11 workings of the soil after planting for the *odd* numbered sections.

Sections 2, 4, 6, 8 and 10, were planted May 2d, harrowed May 19th, Breed's weeder used May 20th and 22d, hand cultivator used June 1st, 12th, 16th and 19th, and hoed on the 20th, cultivated on the 29th, and hoed on the 30th. The *even* numbered sections were worked ten times after planting.

Paris green and Bordeaux mixture were applied three times each, as already stated. September 28th the crop was dug, and the following table gives the yields, in weights and numbers, of tubers:

TABLE IV.

Showing the Weights and Numbers of Tubers Grown upon Sections 1 to 10, inclusive, in Cultural Experiment with Potatoes, 1896.

	No. of Section.	Depth of Spading.	WEIGHT.			NUMBERS.		
			Total.	Large.	Small.	Total.	Large.	Small.
Ground thoroughly worked, eleven times after planting.	1	4	119.75	81.25	38.50	620	261	359
	3	8	132.00	88.00	44.00	653	277	376
	5	12	117.25	76.25	41.00	587	236	351
	7	15	121.75	80.50	41.25	602	250	352
	9	18	125.00	79.50	45,50	630	266	364
Total.	....	....	615.75	405.50	210.25	3,092	1,290	1,802
Average.	......	....	123 15	81.10	42.05	618.4	258	360.4
Ground less thoroughly worked, ten times after planting.	2	4	124.00	80.50	43.50	656	257	399
	4	8	118.00	75.75	42.25	607	249	358
	6	12	119.00	78.00	41.00	594	243	351
	8	15	127.50	89.00	38.50	619	294	325
	10	18	133.25	92.75	40.50	656	300	356
Total.	....	....	621.75	416.00	205.75	3,132	1,343	1,789
Average.	......	.....	124.35	83.20	41.15	626.4	268.6	357.8

The average differences are small, due, perhaps, to the seasonable rains which fell during the growing season. There was a total rainfall, during the months of May, June and July, of 11.04 inches, so that the plants were abundantly supplied with moisture at every period of their growth, and any marked difference resulting from frequent cultivation and the maintenance of a dry earth mulch, which might fairly be expected in a very dry season, did not appear. Indeed the deeper cultivation seems to have been

slightly injurious, as, if we reduce the yields to bushels per acre, we find that the even numbered sections gave an average total yield of 334.36 bushels per acre, of which 223.71 bushels were classed as large and 110.65 bushels as small. On the odd numbered sections the average total crop was 3.23 bushels *less*, and the large tubers 5.65 bushels *less*, but the small tubers 2.42 bushels *more*, per acre, than in the case of the even numbered sections. There were more small potatoes and less large ones where the deepest cultivation was given. The deeper cultivation gave 65.55 per cent. of the crop in large tubers, and the shallow cultivation 66.91 per cent.

Second Year, 1897.

The same plan was followed, in all respects, as in 1896, excepting that a little more seed was used. The data in regard to preparation of ground, fertilization and planting may be found on page 328. The sets were planted on April 30th, Breed's weeder was used on all sections alike, before and while the potatoes were "breaking ground." The after cultivation was with a hand cultivator, and performed in the same way as in 1896.

On sections 1, 3, 5, 7 and 9, Breed's weeder was used May 5th, 17th and 22d, hand cultivator June 5th, 8th, 10th, 16th, cultivated and hoed on the 18th, cultivated on the 22d, and a final hoeing given on July 3d, making 10 workings after planting.

Sections 2, 4, 6, 8 and 10, had the same cultivation with Breed's weeder on May 5th, 17th and 22d, hand cultivation on June 5th, 10th, 16th, and were cultivated and hoed on the 18th, and again on July 3d, making a total of 8 workings. Paris green was applied 4 times and Bordeaux mixture 6 times. The potatoes suffered considerable damage from blight, as frequent rains washed off the Bordeaux mixture, leaving the vines more or less exposed in spite of the repeated spraying. The potatoes were dug September 22d, and the results are given in table V.

TABLE V.

Showing the Weights and Numbers of Tubers grown upon Sections 1 to 10, inclusive, in Cultural Experiment with Potatoes, 1897.

	No. of Section.	Depth of Spading.	WEIGHT. Total.	WEIGHT. Large.	WEIGHT. Small.	NUMBER. Total.	NUMBER. Large.	NUMBER. Small.
Ground thoroughly worked ten times after planting.	1	4	90.25	39 0	51.25	1,060	218	842
	3	8	97.55	55.0	42.55	920	311	609
	5	12	96.50	59.0	37.50	893	318	575
	7	15	87.00	55.5	31.50	780	314	466
	9	18	92.00	51.5	40.50	903	285	618
Total........	....	... .	463.30	260.0	203.30	4,556	1,446	3,110
Average......	....	......	92 66	52.0	40.66	911.2	249.2	622
Ground less thoroughly worked, eight times after planting.	2	4	95	48	47	1,059	280	779
	4	8	96	61	35	911	343	568
	6	12	93	57	36	779	297	482
	8	15	95	54	41	950	302	648
	10	18	96	55	41	897	318	579
Total........	....	....	475	275	200	4,596	1,540	3,056
Average......	....	....	95	55	40	919.2	308	611.2

As in 1896, the less thorough cultivation gave the larger crop in total yield and large potatoes, but the thorough cultivation gave a slightly larger yield of small potatoes. The gains were not large, however, as the total average yield on the even numbered sections, reduced to bushels per acre, exceeded that of the odd numbered by 6.28 bushels, and of large tubers by 8.07 bushels. On the other hand the odd numbered sections gave an average yield of small tubers 1.79 bushels in excess of the yield from the

even numbered sections. We have placed the yields for both years in table VI, calculated to bushels per acre for better comparison.

TABLE VI.

Showing Average Yields of Potato Tubers in Bushels per Acre upon Sections More or Less Thoroughly Cultivated in 1896 and 1897.

	Year.	No. of Workings.	Bushels Per Acre.		
			Total.	Large.	Small.
Calculated from average of yields from sections 1, 3, 5, 7 and 9.	1896	11	331.18	218.06	113.07
	1897	10	249.15	139.81	109.47
Total.	......	....	580.28	357.87	222.47
Average	......	....	290.14	178.93	111.20
Thorough cultivation shows increase of small potatoes.	....	......	....	....	2.10
Calculated from average of yields from sections 2, 4, 6, 8 and 10.	1896	10	334.36	223.71	110.65
	1897	8	255.43	147.88	107.55
Total	......	......	589.79	371.59	218.20
Average	....	......	294.89	185.79	109.10
Less thorough cultivation shows increase of total crop & large tubers.	......	....	4.75	6.86	....

The average for the two years shows the same conclusion as the figures of each year separately. The less thorough cultivation has given an average total yield of 4.75 bushels and 6.86

bushels of large tubers *greater* than the average crop produced by the sections given deeper and more frequent cultivation, while the latter exceeded the former in yield of small tubers by 2.10 bushels per acre. The excess of small tubers in the crops produced by the sections given the more frequent and deeper cultivation is, perhaps, due to the interference with all root growth within four inches of the surface of the ground. The thorough cultivation produced the greatest number of small potatoes, as the total number produced by the odd numbered sections in the two years was 4,912 (large tubers 2,736), while upon the even numbered sections there were only 4,845 (large tubers 2,883). The even numbered sections, however, produced the greater total number of potatoes, so that the deeper cultivation and possible root forming does not appear to have stimulated the plants to form a greater number of tubers at the expense of size. It is probable that the frequent interference with root growth in some degree checked the development of the tubers. While the maintenance of a dry earth mulch, that is, an inch or two in depth of finely pulverized soil on the surface, is highly essential to the preservation of moisture, especially in a dry season, too deep or unnecessarily frequent cultivation is rather injurious than otherwise, as the ground is packed by the treading of horses, and too deep cultivation interferes with root growth. In any case weeds should never be allowed to grow or a crust to form on the surface after rains, as both will draw heavily upon the moisture in the soil, *all* of which is needed by the potato crop. It is well to note that in the above experiment the smaller amount of cultivation comprised the stirring of the earth 10 times in 1896, and 8 times in 1897, which is two or three times as much cultivation as many farmers give the potato crop. Doubtless the amount of cultivation usually given could be considerably increased, with profit. The thorough preparation of the soil before the crop is planted should never be neglected, as increased after cultivation can never make that omission good.

Cultivation experiments with potatoes have, for the past three

years, been conducted at the experiment station connected with Cornell University, Ithaca, N. Y., and the results are given in bulletins Nos. 130 and 140. The conclusions reached are in harmony with our results and we briefly summarize as follows:

Average Yield per Acre for 1895.

4 plots cultivated 18 times........................	337.5 bushels.
4 " " 9 "	367.5 "

Average Yield per Acre for 1896.

Plots cultivated 11 times........................	335.9 bushels.
" " 7 "	343.1 "
" " 3 "	275.2 "

Yield per Acre for 1897.

Carman No. 3—Cultivated level 8 times.............	357 bushels.
" " " " 5 "	349 "
Rural New Yorker No. 2—Cultivated level 7 times..	347 "
" " " " " " 5 " ..	305 "
Rose of Sharon—Cultivated level 7 times..........	320 "
" " " " " 5 "	311 "
Carman No. 3—Cultivated level 5 times..............	325 "
" " " " 4 " and hilled....	288 "

The two last mentioned were treated in every way alike up to the end of the fourth cultivation, after which time one plot received a fifth level cultivation and the other had the rows hilled. The crop sold for sixty-five cents a bushel, out of the field, and the difference in yield represents a loss of $24 per acre, by hilling in place of level culture.

Respecting the results obtained in 1897, Prof. Roberts says:[1] "The general results with culture verify the results obtained in 1896, *i. e.*, that in the ordinary season about seven to nine cultivations, with a fine toothed implement, are likely to give best results. As the vines of the potatoes spread so as to cover a portion of the

[1] Cornell University, Bull. No. 140, p. 391.

space between the rows, the cultivating implement should be made narrower, so that it will not come into too close contact with the plants."

THE EFFECT OF PLANTING SETS AT GREATER OR LESS DISTANCES, AS SHOWN IN THE YIELD OF POTATOES.

In Bulletin No. 31, issued by this Station, the question of how far apart potato sets should be planted, in order that the most remunerative yields might be secured, was considered, and the fact noted that European potato growers, as a rule, plant much closer than is the usual custom in the United States, and generally get much larger yields per acre. The most thorough preparation of the ground and fertilization must, of necessity, accompany close planting. Very many experiments have been tried to determine the best size of set for profit, and whether it should be whole or cut, and the general conclusion reached has been that the total crop increases with the amount of seed planted, but when large amounts of seed are used the increased crop often does not pay the increased cost of seed, and also that the increase in the total crop shows an increased percentage of small and unmarketable potatoes.[1] Experiments by Arthur[2] show that the weight of the set has a greater influence on the product than the number of eyes—the heavier the piece the larger the yield, regardless of the number of eyes. As the bulk of potatoes, used for seed in this State, is brought in from the north, and consists of tubers of marketable size, they are generally cut into pieces of from one to three ounces in weight for planting.

For this experiment it was decided to secure tubers as nearly uniform in size as possible, and then cut them into pieces of a practically uniform weight of a trifle more than one ounce, and plant the same number of sets in each case for comparison.

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[1] Handbook of Experiment Station work, page 275.

[2] Bulletin No. 42, Indiana Ag'l Exp't Station.

First Year, 1896.

Sections 11 to 16, each 12.1 by 30 feet, laid out at the south end of plot 16 before referred to, were assigned to this experiment, and the soil was thoroughly dug over, by hand labor with a spade, to the depth of 12 inches, on April 30th and May 1st. The subsoil was broken up and left at the bottom, while the surface soil was inverted. Fertilizer, at the rate of 1,815 lbs. per acre, was applied broadcast and harrowed in. The fertilizer was compounded from the following materials: Nitrate of soda, 105 lbs.; tankage, 750 lbs.; dissolved phosphate rock, 540 lbs.; fine ground bone, 120 lbs.; and muriate of potash, 300 lbs. The analysis was about as follows: Nitrogen, 3.23 per cent.; available phosphoric acid, 7.91 per cent.; and potash, 8.37 per cent. The plan drawn out for the experiment contemplated the planting of sections 11, 12 and 13, with rows 30 inches apart, and the sets respectively 9, 12 and 16 inches apart, while the remaining three sections, 14, 15 and 16, were to be planted with rows 24 inches apart, and the sets 9, 12 and 16 inches apart, as in the other case. By some misunderstanding, however, the planting was done as follows: Sections 11 and 12, four rows each, in one case 24 inches and in the other 30 inches apart, and the sets 9 inches apart in the row—320 sets on the two sections. Numbers 13 and 14 had the same number of rows the same distance apart, but the sets were placed 12 inches apart in the drill—240 sets on the two sections. On sections 15 and 16 there were the same number of rows and the same distances apart, but the sets were placed 16 inches apart, or 180 in all. Drills were marked out with a line and made 4 inches deep by hand. The sections were planted May 4th, and the sets were covered by hand. Cultivation was done with a smoothing harrow May 19th, and with Breed's weeder the 20th and 22d. May 28th the potato beetles were gathered by hand from the young plants. May 29th sections 11, 13 and 15, were cultivated with a two-wheeled hand cultivator, and all the sections were cultivated by hand on June 1st, 12th, 16th, 19th and 29th, and the

potatoes were hand hoed, and all weeds which had escaped the cultivator removed, on June 20th and 30th. Paris green was applied with a powder duster June 26th and July 4th and 14th. Bordeaux mixture was applied with a spraying pump on July 23d, 28th and 31st. The potatoes were dug, assorted and weighed, on September 28th. It is evident to the reader that if the sets are cut to a practically uniform size it will take much more seed to plant closely, that is, 9 by 24 or 30 inches, than to plant 16 by 24 or 30 inches, and, therefore, there must be more than a corresponding increase in crop to make the operation profitable. To eliminate the question of the difference in weight of seed used from the problem, we have subtracted, in each case, from the weight of marketable tubers produced, the weight of sets planted, and the calculation of yields per acre is based on the net weights so obtained.

After deducting the weight of seed used in each case from the product of large tubers, it is found that the sets planted at the greatest distance have given the smallest yield per acre. The sets planted nine inches apart in the drills gave a net yield of 192.99 bushels of marketable tubers. When the sets were placed twelve inches apart there was a net decrease of 6.52 bushels, and when placed sixteen inches apart in the drill the net decrease was 19.56 bushels of marketable potatoes. Calling the yield of large tubers from the nine inch planting 100 per cent., that from the twelve inch planting was equal to 96.62 per cent., and that from the sixteen inch planting only 89.86 per cent.

EXPERIMENT OF 1897.

The same portion of plot 16 was used for the work as was used the previous year, and the same variety of potatoes—Queen—was planted. The soil was prepared for planting by spading it to the depth of twelve inches, keeping the subsoil at the bottom, as was done in 1896. The spading was done on April 26th, and the fertilizer applied evenly broadcast and well worked into the soil

TABLE VII.

Showing the Yields of Potato Tubers from Sets Planted at Different Distances. Experiment of 1896.

Number of Sections and Distance of Planting.	No. of Sets.	Average Weight of Set in Ounces.	Pounds of Sets per Plot.	Bushels of Sets per Acre.	Pounds of Tubers per Plot, and Bushels per Acre. Total.	Large.	Small.	Number of Tubers. Total.	Large.	Small.
Sections 11 and 12. { 4 rows 9×30 inches .. / 4 rows 9×24 inches .. }	320	1.035	20.70	....	262.00	170.25	91.75	1,371	560	811
Deduct weight of sets planted.......	....	....	......	....	....	20.70	... .	......	....	......
						149.55				
Calculated net[1] yield, in bushels, per acre...	.....	.....	......	27.83	316.84	192.99	123.35	......	...	....
Sections 13 and 14. { 4 rows 12×30 inches. / 4 rows 12×24 inches. }	240	1.12	16.8	.. ....	245.75	155.50	90.25	1,185	506	679
Deduct weight of sets planted	. ....	. .	.....	....	. ...	16.8	....	.....	....	......
						138.70				
Calculated net[1] yield, in bushels, per acre...	.....	.....	....	22.58	307.80	186.47	121.33	.....	.....	.. ...
Sections 15 and 16. { 4 rows 16×30 inches. / 4 rows 16×24 inches. }	180	1.073	12.0	... .	233.75	141.00	92.75	1,080	446	634
Deduct weight of sets planted	......	......	.....	.. ..	....	12.00	... ...	.....	......	......
						129.00				
Calculated net[1] yield, in bushels, per acre...	.... .	......	.....	16.13	298.12	173.43	124.69	......	....	......

[1] Seed used deducted from product of large potatoes; 540 square feet of land occupied by the crop in each case.

before the potatoes were planted, April 30th. The fertilizer used was of the same composition and weight as in the 1896 trial. Furrows were marked out by hand at exact distances, and a surveyor's chain used to regulate the distance of the sets in the furrow. The various sections were planted in accordance with the plan originally adopted and here given in table VIII.

TABLE VIII.

Showing Number, Average Weight and Distance of Planting Potato Sets, and Rate of Seeding per Acre in Bushels in 1897.

No. of Sections.	No. of Drills on each Section.	Sets. Inches Apart in Drills.	Drills. Inches Apart.	No. of Sets on each Section.	Pounds of Sets on each Section.	Average Number of Sets in Ounces.	Bushels of Sets Per Acre.
11	5	9	30	200	23.	1.84	44.53
12	5	12	30	150	17.	1.81	32.91
13	5	16	30	110	12.	1.75	23.23
14	6	9	24	240	26.	1.73	52.
15	6	12	24	180	20.	1.77	40.
16	6	16	24	132	13.5	1.63	27.

May 5th, 17th and 22d, Breed's weeder was used to stir the soil and destroy any germinating weed seeds. June 3d a hand wheel cultivator was used, and the potatoes were hoed. On the 10th and 16th the hand cultivator was used, and the sections were cultivated and hoed on the 18th and again on July 3d. Paris green was applied on June 17, July 3d and 8th. The vines were sprayed with Bordeaux mixture six times as follows: July 3d, 15th, 19th, 24th, August 3d and 9th. Frequent rains washed off much of the Bordeaux mixture, and, in spite of the repeated spraying, blight injured the crop by causing a somewhat premature decay of the vines. September 27th the potatoes were dug, assorted, weighed

and counted, all tubers weighing two ounces or more were classed as "large," and those weighing less than two ounces as "small."

TABLE IX.

Showing the Weights and Numbers of Potato Tubers Produced by Sets Planted at Different Distances. Experiment of 1897.

No. of Section.	Inches Apart Sets were Planted.	Pounds of Sets.	Pounds of Tubers per Section.				No. of Tubers per Section.		
			Total.	Large.	Large.[1]	Small.	Total.	Large.	Small.
11	9×30	23.	132.25	56.	33.	76.25	1,580	335	1,245
12	12×30	17.	126.	69.	52.	57.	1,298	419	872
13	16×30	12.	124.	73.	61.	51.	1,196	405	791
14	9×24	26.	147.	69.5	43.5	77.5	1,568	430	1,138
15	12×24	20.	149.5	82.75	62.75	66.75	1,512	434	1,078
16	16×24	13.5	152.	103.	89.50	49	1,332	572	760

The weight of the large potatoes is given, and also in the next column the weight of large tubers after deducting the weight of the sets used in planting, which brings the results down to a basis suitable for comparison. Taking the drills planted 30 inches apart, it will be noticed that there is a steady increase in yield from the sets planted 9 inches apart up to those planted 16 inches apart, and the same thing holds true in the case of the drills planted 24 inches apart. The differences will, perhaps, be more prominent if the yields are calculated to bushels per acre.

[1] This column shows the weight of large tubers after subtracting the pounds of sets used in planting, that is, it is the net weight of the crop, and is used as the basis for calculating the yields per acre.

TABLE X.

Showing Yields of Potato Tubers in Bushels, per Acre, from Sets planted at Different Distances in 1897.

No. of Section.	INCHES APART SETS WERE PLANTED.	Bushels of Sets per Acre.	BUSHELS OF TUBERS PER ACRE.		
			Total.	Large.[1]	Small.
11	9 × 30	44.58	211.50	63.88	147.62
12	12 × 30	32.91	211.02	100.67	110.35
13	16 × 30	23.23	216.82	118.09	98.73
14	9 × 24	52.—	242.—	87.—	155.—
15	12 × 24	40.—	259.—	125.50	133 50
16	16 × 24	27.—	277.—	179.—	98.
11, 12, 13	Drills planted 30 inches apart averaged		213.11	94.21	118.90
14, 15, 16	Drills planted 24 inches apart averaged		259.33	130.50	128.83
11, 14	Sets planted 9 inches apart averaged.		226.75	75.44	151.31
12, 15	Sets planted 12 inches apart averaged.		235.01	113 08	121.92
13, 16	Sets planted 16 inches apart averaged.		246.91	148.54	98.36

The reader will notice in this table that there is, without exception, an increase in large potatoes and a decrease in small ones, as the distance between the sets increases. The proportion of small potatoes is very large, indicating that the growth was interrupted before full maturity was reached. Had the crop of 1897 been less affected by blight and reached the same stage of maturity as the crop of 1896, the results might not, and, probably, would

[1] Weight of sets used for planting has been deducted.

not have been, as they are, exactly opposite of results secured then. It is quite evident, in the case of sections 11 and 14, when the sets were planted 9 inches apart and the average yield of large tubers was only 75.44 bushels and the small ones 151.31 bushels, that, could that quantity of small potatoes have had two weeks additional growth, very many of them would have become large potatoes, and the total yield would have been much increased, probably exceeding the yield where the sets were planted 16 inches apart, as was the case last year. The average yield from the three sections, where the drills were made 24 inches apart, was 36.29 bushels of large potatoes greater than the average yield of the 30 inch drills, and it will be noticed that in this trial section 16, where the sets were planted 16x24 inches, gave the largest total yield, the largest yield of large potatoes and the smallest yield of small ones. Whether the more even distribution of the plants on the section, in this case, allowed the sunshine to enter, and promoted a healthier, tougher growth of vine, and hastened the maturity of the tubers, is a point worthy of note. It has been repeatedly shown that an excess of nitrogenous manures will cause a rank, succulent growth of vines, very susceptible to blight, and close planting on rich ground might, in a wet season, produce a tender growth of tops, less able to resist disease than those plants having more room and air. So far as one could judge by inspection and appearances while growing, there was no perceptible difference either in growth of tops or effect of blight upon the different sections. These sections were carefully sprayed with Bordeaux mixture six times, and, could it have remained on the vines instead of being washed off by rains, we believe that the results would have been more favorable to the closer planting, and thus accorded with the work of last season.

SUMMARY.

Spading Different Depths, 1896.—The greatest yield of total crop was on the section spaded 18 inches deep, followed by the section

spaded 8 inches deep, and the third place was taken by the 15 inch spading.

The largest yield of marketable potatoes was also from the 18 inch spading, the 15 inch gave second best yield, and the 8 inch spading held third place.

Spading Different Depths, 1897.—The yields were more uniform than they were the previous year. The greatest total yield was on the 8 inch spading, the 12 inch ranking second, and the 18 inch spading third.

There was greater relative difference in the yield of large tubers. The sections spaded 8 and 12 inches deep gave equal weights of large tubers, the 15 inch spading ranking second, the 18 inch third, and the 4 inch spading last, with a yield considerably below the best.

An average of the yields from the two years' trial, calculated into bushels per acre, gives the following result as the average total crop: 18 inch spading, 300.22 bushels; 8 inch spading, 297.63 bushels; 15 inch spading, 289.89 bushels; 4 inch spading, 288.38 bushels; and 12 inch spading, 286.34 bushels.

The average yield of large tubers in bushels per acre for the two years was as follows: 15 inch spading, 187.55 bushels; 18 inch spading, 187.34 bushels; 8 inch spading, 186.70 bushels; 12 inch spading, 180.32 bushels; and the 4 inch spading, 158.85 bushels.

The 8 inch spading exceeds the 4 inch by 9.25 bushels in average total crop, and 27.85 bushels in average yield per acre of large tubers.

The average yield of large tubers on the 8 inch spading is only exceeded by that on the 15 inch spading .85 of a bushel, and by that of the 18 inch spading .64 of a bushel.

The Effect of More and Less Thorough Cultivation, 1896.—Seasonable rains kept the ground moist, and there was but little difference in yields of tubers. Thorough cultivation of the soil 11 times, between planting and digging, gave a smaller crop than less

thorough cultivation 10 times. The smaller amount of cultivation gave a total crop, calculated from the average of five sections, 3.23 bushels per acre greater than the average of the five thoroughly cultivated sections, and of large tubers 5.65 bushels greater. The very thorough cultivation, however, exceeded in average yield of small potatoes by 2.42 bushels per acre.

The Effect of More and Less Thorough Cultivation, 1897.—The results corroborate those of last year. The total average yield of the five less thoroughly cultivated sections was 6.28 bushels, and of large tubers 8.07 bushels per acre greater than the average of the five thoroughly cultivated sections, but the latter exceeded the former in yield of small potatoes by 1.79 bushels per acre.

The average results for the two years show that less thorough cultivation gave 4.75 bushels more total crop and 6.86 bushels more large tubers than the more frequent and deeper cultivation, while the latter gave an excess of 2.10 bushels of small potatoes.

The less thorough cultivation produced the greater total number of tubers and the greater number of large tubers, while the thorough cultivation exceeded in number of small potatoes.

Less thorough cultivation included working the soil to a depth of about two inches, ten times in 1896 and 8 times in 1897, after the potatoes were planted.

Thorough cultivation comprised the working of the soil to a depth of four inches, 11 times in 1896 and 10 times in 1897, after planting the potatoes.

The Effect of Planting Sets at Greater or Less Distances, 1896.—Sets of a practically uniform size were planted in an equal number of drills, 24 and 30 inches apart. The sets were placed at three different distances in the drills, viz.: 9, 12 and 16 inches. After deducting from the yield of large tubers the weight of sets planted in each case, the sets planted 9 inches apart produced at the rate of 192.99 bushels per acre of large potatoes, or 6.52 bushels more than the 12 inch planting, and 19.56 bushels more than the 16 inch planting. If the yield from the 9 inch spading is represented by

100 per cent., that from the 12 inch would be 96.62 per cent., and the 16 inch 89.86 per cent.

The Effect of Planting Sets at Greater or Less Distances, 1897.— The results are the reverse of those obtained in 1896. There is an increase in the crop of large tubers, in every case, from the 9 inch spacing of sets in the drill up to the 16 inch planting. The blight evidently interfered with the full development of the tubers. Drills planted 24 inches apart averaged 36.29 bushels per acre more, in net yield of large tubers, than when the drills were 30 inches apart. Sets planted 9 inches apart gave an average yield of 75.44 bushels of large tubers and 151.31 bushels per acre of small ones. Sets planted 12 inches apart gave an average yield of 113.08 bushels of large, and 121.92 bushels of small, potatoes per acre. Sets planted 16 inches apart produced an average crop of 148.54 bushels of large tubers and 98.36 bushels of small ones. Planting sets 16x24 inches produced the largest total yield, the largest yield of marketable tubers, and the smallest yield of small potatoes.

FERTILIZER EXPERIMENT WITH POTATOES.

CHAS. O. FLAGG, G. M. TUCKER, AND J. A. TILLINGHAST.

The large amount of fertilizer used in the growing of early potatoes, in certain sections of this State, and the great variation in the composition of the potato and root fertilizers offered for sale, led to a trial of the effect upon the potato crop of changes in the composition of the fertilizer used. The following is compiled from Bulletin No. 39, and serves to show how wide the range of composition, in 30 different brands, was found to be:

Analyses of 30 Brands of Potato and Root Fertilizers, Collected under the Fertilizer Inspection Law, in 1896.	Per cent. of Nitrogen.	Per cent. of Available Phosphoric Acid.	Per cent. of Potash.
Minimum	1.82	5.27	2.48
Maximum	5.01	10.47	10.80
Average	3.12	7.81	6.12

A less number of brands, analyzed in 1895, gave an average of 3 per cent. nitrogen, 7.67 per cent. available phosphoric acid, and 6.05 per cent. of potash—slightly lower in all the ingredients than the average in 1896. It was thought best to take the average of 1896 as a basis, and increase the per cent. of phosphoric acid, vary the form and amount of potash, and also vary the form of the nitrogen used.

Plot 38 was selected as best adapted to the experiment, and a

brief review of its history is here given. The soil is a sandy loam well drained by a gravel subsoil. In 1890 the plot was a portion of a field producing a very thin and light crop of fine grass, mainly Rhode Island bent. Immediately after haying the sod was broken up by plowing from 5 to 6 inches deep—the full depth of the agricultural soil—and left unharrowed until the spring of 1891, when the permanent plots were staked out. That season the plots were not manured. White field beans were planted. In 1892 white flint field corn was planted, May 18th, without any application of manure in order to secure some record of the natural fertility of the plot. The growth was very meager, the stalks growing only 12 to 24 inches high, and no grain was formed. At time of cutting, September 21–23, the total weight of the green fodder produced by the one-tenth acre was 43 lbs.

In 1893 the plot was planted to cow-peas. Fertilizer at the rate of 1,200 lbs. of dissolved phosphate rock and 150 lbs. of nitrate of soda per acre was applied. No potash was used, as experiments had shown our soil to be quite well supplied with that constituent. The cow-peas were plowed under for a fertilizer. In 1894 corn was planted, and 750 lbs. of dissolved phosphate rock and 150 lbs. of nitrate of soda per acre used as a fertilizer. The yield of corn per acre was as follows: hard corn, 46.68 bushels; soft corn, 14.14 bushels; and stover, 3,592.2 pounds. This corn crop shows how much improvement in the soil had resulted from the green manuring with cow-peas and the two applications of fertilizer.

In 1895 the plot was used for an experiment with oat-smut. A fertilizer was applied, made according to the following formula for an acre: nitrate of soda, 300 pounds; dissolved phosphate rock, 240 pounds; fine ground bone, 180 pounds; and muriate of potash, 120 pounds.

FERTILIZER EXPERIMENT WITH POTATOES, 1896.

For the purpose of this experiment plot 38 was divided into 8 sections, each 20x30 feet in area, and separated by paths 4.2 feet wide. These sections were numbered, consecutively, from 1 to 8,

beginning at the north end. The ground was plowed, on April 27th, with a sulky swivel plow, to the depth of the agricultural soil. The fertilizer used as a standard contained 3.2 per cent. nitrogen, 8 per cent. of available phosphoric acid, and 6.48 per cent. of potash. The necessary quantity of each ingredient to secure that quality is designated as 1, if doubled it is styled 2, and if halved it is called ½. The standard fertilizer, as applied to section 4, was used at the rate of 1,678.51 lbs. per acre. The weights per section, with the net weights of the three elements provided, are as follows:

Material Used for Fertilizer.	Ration.	Rate Per Acre. Pounds.	One Ration Per Section. Pounds.	Pounds, net, in one Ration Per Section.
Muriate potash	1	207	2.85	1.5 lbs. potash.
Sulfate potash	1	209	2.88	1.5 " potash.
Dissolved phosphate rock	1	1,080	14.87	1.85 " available phosphoric acid.
Nitrate soda	1	392	5.40	0.74 " nitrogen.
Dried blood	1	452	6.22	0.74 " nitrogen.

The arrangement of the sections, the weights of fertilizer applied, and the percentage composition, are given in table I, as follows:

TABLE I.

Showing the Kinds and Weights, in Pounds, of Fertilizer, used in Growing Potatoes on Plot 38, in 1896, with the Percentage Composition of Fertilizer Used on each Section.

No. of Section.	MATERIALS USED FOR FERTILIZER.	Ration.	Weight of Materials.	Net Weight of: Nitrogen.	Net Weight of: Available Phos. Acid.	Net Weight of: Potash.	Percentage Composition: Nitrogen.	Percentage Composition: Available Phos. Acid.	Percentage Composition: Potash.
1	Muriate potash.......	1	2.85	...	......	1.50	3.14	7.86	6.37
	Dis. phosphate rock..	1	14.87	....	1.85	....			
	Dried blood	½	3.11	.37	......	....			
	Nitrate soda..........	½	2.70	.37	......	....			
2	Muriate potash......	½	1.43	.. .	......	.75	3.19	7.99	6.48
	Sulfate potash.... ..	½	1.44	....	......	.75			
	Dis. phosphate rock..	1	14.87	....	1.85	....			
	Nitrate soda.........	1	5 40	.74	....	. ..			
3	Muriate potash.......	1	2.85	....	....	1.50	3.09	7.73	6.22
	Dis. phosphate rock..	1	14.87	...	1.85	...			
	Dried blood..........	1	6.22	74	......	...			
4	Muriate potash.......	1	2.85	....	.....	1.50	3.20	8.00	6.48
	Dis. phosphate rock..	1	14 87	...	1 85	....			
	Nitrate soda..	1	5.40	74	.....	....			
5	Muriate potash.......	2	5.70	....	.....	3.—	2.85	7 12	11.55
	Dis. phosphate rock..	1	14.87	....	1.85	....			
	Nitrate soda.....	1	5.40	.74	.....	....			
6	Muriate potash.......	1	2.85	.. ..	......	1.50	1.94	9.73	3.94
	Dis. phosphate rock..	2	29.74	....	3.70	....			
	Nitrate soda..........	1	5.40	.74	......	....			
7	Muriate potash.......	1	2.85	....	......	1.50	1.40	10.50	2.83
	Dis. phosphate rock..	3	44.61	. ..	5.55	....			
	Nitrate soda..	1	5.40	.74	.....	....			
8	Sulfate potash..	1	2.88	....	.....	1.50	3.19	7.99	6.48
	Dis. phosphate rock..	1	14.87	....	1.85	....			
	Nitrate soda..........	1	5.40	.74	.....	....			

The fertilizer was carefully weighed and mixed for each section, applied broadcast April 28th, and well worked into the soil with a cultivator, each section being worked separately to prevent any dragging or mixing of the earth of different sections. Eight rows, running east and west, were laid out on each section, 30 inches apart, and opened 4 to 5 inches deep by hand. Queen potatoes were planted, the seed tubers being cut to a uniform size of two ounces and placed in the drills 16 inches apart, then covered by hand. The planting was done April 29th. On May 19th a smoothing harrow was used on the sections, and Breed's weeder on the 20th and 22d. On June 1st the potatoes were hand cultivated, and hoed on the 2d. On the 12th and 16th they were cultivated, hoed on the 19th, and cultivated for the last time June 29th. What potato beetles could be found were gathered by hand, on May 27th, when the vines were small. On June 26th Paris green was applied with a powder duster, and again on July 4th and 14th. The vines were sprayed with Bordeaux mixture four times, on the following dates: July 11th, 23d, 28th and 31st. The growth on all the sections was vigorous, and little difference was noticeable, excepting shades of color in the foliage, which difference is noted in a column in table II. The potatoes were dug on September 25th, assorted, those weighing two ounces or more classed as large, and those of less weight as small, and weighed. The results are given in table II.

TABLE II.

Showing Color of Vines, and Weights and Numbers of Potato Tubers Grown in Fertilizer Experiment on Plot 38, 1896.

No. of Section.	Fertilizing Materials.	Ration.	Color of Vines Aug. 27th.	Weights of Tubers in Pounds.			Numbers of Tubers.		
				Total.	Large.	Small.	Total.	Large.	Small.
1	Muriate potash Dis. phosphate rock Dried blood Nitrate soda	1 1 ½ ½	Green.	283.75	169.50	64.25	1,048	537	511
2	Muriate potash Sulfate potash Dis. phosphate rock Nitrate soda	½ ½ 1 1	Dark Green.	256.25	181.50	74.75	1,079	539	540
3	Muriate potash Dis phosphate rock Dried blood	1 1 1	Light Green.	242.25	171.00	71.25	1,143	542	601
4	Muriate potash Dis. phosphate rock Nitrate soda	1 1 1	Green.	244.25	160.00	80.25	1,179	486	693
5	Muriate potash Dis. phosphate rock Nitrate soda	2 1 1	Light Green.	247.25	170.50	76.75	1,058	510	548
6	Muriate potash Dis. phosphate rock Nitrate soda	1 2 1	Green.	259.50	180.50	79.00	1,164	532	632
7	Muriate potash Dis. phosphate rock Nitrate soda	1 3 1	Dark Green.	254.75	180.25	74.50	1,069	560	509
8	Sulfate potash Dis. phosphate rock Nitrate soda	1 1 1	Very Dark Green.	266.50	186 50	80.00	1,233	563	670

Several questions are involved in this experiment. We will briefly name them here, with the numbers of the sections bearing upon each, and allow the discussion of them to follow the record of this experiment for 1897.

1. What was the effect upon growth and yield of tubers of muriate of potash as compared with the sulfate of potash? Compare sections 2, 4 and 8.

2. What was the effect of increasing the ration of muriate of potash? Compare sections 4 and 5.

3. What was the effect of increasing the ration of phosphoric acid? Compare sections 4, 6 and 7.

4. What was the effect of dried blood, as a source of nitrogen, when compared with nitrate of soda? Compare sections 1, 3 and 4.

FERTILIZER EXPERIMENT WITH POTATOES, 1897.

The work upon plot 38 was continued, in 1897, according to the plan followed in 1896. The ground was thoroughly plowed April 26th, and harrowed with a disk harrow. Slight differences in the chemicals and materials used for fertilizer made a change in the weights of each necessary in order that the same weights of actual nitrogen, phosphoric acid and potash, should be used as in 1896.

The rate of application of one ration per acre, in 1897, was as follows:

Muriate potash	214.89	pounds.
Sulfate potash	296.51	"
Dissolved phosphate rock	874.10	"
Nitrate soda	343.39	"
Dried blood	488.50	"

Such changes in weights of materials, of course, made changes in percentage composition. The changes per section may be noted by comparing table III with table I, on page 355. The percentage composition is higher in every case, the result of greater concentration in the fertilizing materials.

TABLE III.

Showing the Kinds and Weights, in Pounds, of Fertilizer, used in Growing Potatoes on Plot 38, in 1897, with the Percentage Composition of the Fertilizer Used on each Section.

No. of Section.	MATERIALS USED FOR FERTILIZER.	Ration.	Weight of Materials.	NET WEIGHT OF: Nitrogen.	NET WEIGHT OF: Available Phos. Acid.	NET WEIGHT OF: Potash.	PERCENTAGE COMPOSITION: Nitrogen.	PERCENTAGE COMPOSITION: Available Phos. Acid.	PERCENTAGE COMPOSITION: Potash.
1	Muriate potash......	1	2.96	....	......	1.50	3.63	9.07	7.36
	Dis. phosphate rock.	1	12.04	....	1.85	....			
	Dried blood.........	½	3.02	.37	......	....			
	Nitrate soda...	½	2.36	.37	.....	....			
2	Muriate potash.. ..	½	1.48	....	.....	.75	3.73	9.33	7.57
	Sulfate potash	½	1.56	....	......	.75			
	Dis. phosphate rock.	1	12.04	....	1.85	....			
	Nitrate soda........	1	4.73	.74	.....	....			
3	Muriate potash......	1	2.96	....	....	1.50	3.51	8.79	7.12
	Dis. phosphate rock.	1	12.04	....	1.85	....			
	Dried blood.........	1	6.04	.74	......	....			
4	Muriate potash......	1	2.96	....	.....	1.50	3.75	9.88	7.60
	Dis. phosphate rock.	1	12.04	....	1.85	....			
	Nitrate soda........	1	4.73	.74	.....	....			
5	Muriate potash......	2	5.92	....	....	3.00	3.26	8.15	12.34
	Dis. phosphate rock.	1	12.04	....	1.85	....			
	Nitrate soda.... ..	1	4.73	.74	......	....			
6	Muriate potash......	1	2.96	....	....	1.50	2.32	11.64	4.72
	Dis. phosphate rock.	2	24.08	....	3.70	....			
	Nitrate soda	1	4.73	.74	.....	....			
7	Muriate potash......	1	2.96	....	......	1.50	1.68	12.66	3.42
	Dis. phosphate rock.	3	36.12	....	5.55	....			
	Nitrate soda........	1	4.73	.74	......	....			
8	Sulfate potash......	1	3.12	....	......	1.50	3.72	9.30	7.54
	Dis. phosphate rock.	1	12.04	....	1.85	....			
	Nitrate soda........	1	4.73	.74	....	....			

The fertilizer for each section, after being weighed and mixed by hand, was spread broadcast, and evenly distributed to its boundaries and not beyond. The fertilizer was thoroughly mixed with the soil by using a cultivator and a hand rake on each section separately. On May 4th "Queen" potatoes were planted, eight drills on each section, 30 inches apart, and the sets placed exactly 16 inches apart in the drills. Seed tubers, each of 4 ounces or more in weight, were selected, 17½ pounds weighed out for each section, and that quantity was then evenly divided into 176 sets in each case. The furrows were made by hand, the sets dropped, using a surveyor's chain to regulate the distance, and covered by hand 4 inches deep. The cultivating was all done with a hand-wheel hoe. They were cultivated four times, as follows: May 10th, 14th and 18th, when a hand hoe was used along the drills, and July 3d, when they were again hoed. May 17th Paris green was applied to the vines with a powder gun; and July 3d they were sprayed with Bordeaux mixture and Paris green. The vines were also sprayed on July 15th, 19th, August 3d and 9th. No perceptible difference, as to size or color of vines, could, this year, be distinguished on the various sections. As was the case with the crop upon plot 16, the potato blight, by destroying the vines, stopped the growth of the tubers before full maturity had been reached, and the yield was less than in 1896. The crop was harvested on September 11th and 12th. As before, 2 ounces was the minimum limit of weight in tubers classed as large. Table IV, which follows, gives the weights and numbers of tubers produced upon the different sections.

TABLE IV.

Showing Weights and Numbers of Potato Tubers Grown in Fertilizer Experiment, on Plot 38, in 1897.

No. of Section.	FERTILIZING MATERIALS.	Ration.	WEIGHTS OF TUBERS IN POUNDS. Total.	Large.	Small.	NUMBERS OF TUBERS. Total.	Large.	Small.
1	Muriate potash.	1	199.25	97.75	101 50	2275	542	1,733
	Dis. phosphate rock ..	1						
	Nitrate soda..........	½						
	Dried blood..........	½						
2	Muriate potash..... ..	½	229 50	120 50	109.00	2440	634	1,806
	Sulfate potash........	½						
	Dis. phosphate rock ..	1						
	Nitrate soda....... ..	1						
3	Muriate potash......	1	210.75	103.00	107.75	2303	566	1,737
	Dis. phosphate rock ..	1						
	Dried blood	1						
4	Muriate potash.	1	229.75	120.25	109.50	2332	632	1,700
	Dis. phosphate rock ..	1						
	Nitrate soda..........	1						
5	Muriate potash.	2	209.00	109.25	99.75	2057	574	1,483
	Dis. phosphate rock ..	1						
	Nitrate soda.	1						
6	Muriate potash......	1	236.50	125.5	111.00	2432	678	1,754
	Dis. phosphate rock ..	2						
	Nitrate soda..	1						
7	Muriate potash......	1	226.50	122.00	104.50	2501	701	1,800
	Dis. phosphate rock ..	3						
	Nitrate soda..........	1						
8	Sulfate potash........	1	205.50	107.50	98.00	2479	624	1,835
	Dis. phosphate rock ..	1						
	Nitrate soda..	1						

We will first consider the effect of *muriate of potash as compared with the sulfate*, and for this purpose we will group together the figures obtained from the crops of the two seasons upon sections 2, 4 and 8. To give a clearer and more definite idea of the yields and differences we have computed the yields in pounds per section into bushels per acre. In the sections under consideration the reader will notice that the applications of dissolved phosphate rock and nitrate of soda were the same for each section, therefore, in the following comparison, we only mention the potash.

Effect of Muriate and Sulfate of Potash upon Potatoes in 1896 and 1897.

No. of Section.	FORM OF POTASH USED.	Ration.	Year.	YIELD OF TUBERS, IN BUSHELS, PER ACRE.		
				Total.	Large.	Small.
2	Muriate potash .... Sulfate potash.........	½ ½	1896	317.10	224.60	92.50
2	Muriate potash .... Sulfate potash.........	½ ½	1897	284.00	149.12	134.88
	Average.	......	......	**300.55**	**186.86**	**113.69**
4	Muriate potash	1	1896	302.26	198.00	104 26
4	Muriate potash	1	1897	284.31	148.80	135 51
	Average.	......	.....	**293.28**	**173.40**	**119.88**
8	Sulfate potash.	1	1896	329.69	230.29	99.40
8	Sulfate potash.........	1	1897	254.30	133.03	121.27
	Average...........	.....	....	**291.99**	**181.66**	**110.33**

Comparing first the yields for 1896, we find that the poorest yield was on section 4, where the muriate alone was used. The next best was on section 2, where one-half the ration was muriate and one-half was sulfate. The increase in yield of marketable potatoes was 26.6 bushels. The best yield was on section 8,

where the sulfate alone was used, and where the increase of large potatoes, over those produced on section 4, was 32.29 bushels. The difference in total crop was not as great, showing a greater proportion of small potatoes on section 4 than on section 8. These yields would indicate that potash, in the form of sulfate, is considerably superior to muriate, but the figures are somewhat modified by the results obtained in 1897. We find that the yields upon sections 4 and 2 are almost identical: section 4 having .31 of a bushel more in total crop, and section 2 having .32 of a bushel more large potatoes. Section 8 produced a smaller crop—the total product being 30.01 bushels less than was produced on section 4, but the difference in yield of large potatoes was only 15.77 bushels. The potash in muriate is always combined with chlorin, the specific action of which, when present in the soil in other than small quantities, is poisonous to plant life. For that reason good authorities advise that liberal applications of muriate of potash are better made in the autumn or very early in the spring, so that opportunity may be afforded for the potash to enter into other combinations within the soil. This may allow the poisonous chlorin, in combination with lime, etc., to be so diluted or leached away by the winter and spring rain as to become harmless. From the foregoing it is easy to understand that the evil effect of muriate of potash, if any, would be greatest in the dryest season, and that, if the season be sufficiently wet, even comparatively heavy applications of muriate would be harmless, provided the soil is well drained and has a sufficient supply of lime. It is interesting, in this connection, to note the difference in rainfall during the two potato growing seasons of this experiment.

Rain-fall in Inches.	1896.	1897.
May	2.92	3.95
June	5.01	4.43
July	3.11	6.35
August	3.67	4.31
Total for four months	14.71	19.04

While in 1896 there was a sufficient amount of rain-fall, so evenly distributed that in this locality the potato crop at no time in its growth suffered for moisture, in 1897 there was an unusual amount of rainfall, so that the season was considered a very wet one. It is not improbable that the difference in the amount of rain-fall may have caused, in part at least, the difference noted in the effect of the two forms of potash used in this experiment. In 1896, the dryer of the two seasons, section 8, where the sulfate of potash was used, produced at the rate of 32.29 bushels of large potatoes more than section 4, where the muriate was used, and on section 2, with one-half the ration in the form of sulfate, there was also a proportional increase in the crop. With a larger rain-fall in 1897 we find practically no difference in the yields of sections 4 and 2, and that of section 8 considerably lower than either. Making an average of the two years we find that the lowest average total yield was on section 8, where the full ration of sulfate was used, but only 1.29 bushels less than the average total yield of section 4. In the crop of large potatoes, however, section 8 exceeds section 4 by 8.26 bushels, showing that the section on which was used the muriate produced a considerably larger proportion of small potatoes. Section 2 produced the greatest average yield both of total crop and large tubers.

No attempt has thus far been made to obtain any data as to the quality of the tubers grown upon the two forms of potash, but it is generally conceded that the chlorin of the muriate tends to

lower the starch content of the tubers and thus injure the quality by making them "soggy" instead of "mealy." In this experiment 214.89 lbs. per acre of muriate were used, in 1897, at a cost of two cents per pound, and to furnish the same amount of actual potash required 226.51 pounds of high grade sulfate, costing two and one-half cents per pound, making the sulfate cost $1.37 more, per acre, than the muriate. Brooks, at Amherst, found that the sulfate gave 22.1 bushels of large potatoes and 1.25 bushels of small ones more, per acre, than muriate, and that the cost was about $2.00 per acre more for the sulfate than for the muriate.

The second point we will consider is *the influence of an increased application of potash*, as illustrated by the yields from sections 4 and 5.

No. of Section.	FORM OF POTASH USED.	Ration.	Year.	YIELD OF TUBERS IN BUSHELS PER ACRE. Total.	Large.	Small.
4	Muriate potash	1	1896	302.26	198.00	104.26
4	Muriate potash	1	1897	284 81	148.80	135.51
	Average..	..	......	**293.28**	**173.40**	**119.88**
5	Muriate potash	2	1896	305.96	210.99	94.97
5	Muriate potash	2	1897	258.63	135.19	123.44
	Average...... ...	...	....	**282.29**	**173.09**	**109.20**

In 1896 section 5, which received the double ration of muriate of potash, produced the larger yield, 3.70 bushels in total crop and 12.99 bushels of large tubers more than section 4, but in 1897 the results were reversed, section 4 out-yielding section 5 by 25.68 bushels in total crop and 13.61 bushels of large potatoes. Had the past season been dry instead of wet, section 5 would, undoubtedly, have shown a very much smaller yield than was secured. The small excess of crop produced upon section 5, in 1896, could

have used only a very small part of the excess of potash which this section received above that supplied to section 4, and, apparently, the second application of the double ration of muriate supplied so much potash in that form as to be prejudicial to the largest crop production.

The third question to be considered is, *what was the effect of increasing the ration of phosphoric acid?* For this purpose we compare the results obtained from sections 4, 6 and 7, which received equal rations of muriate of potash and nitrate of soda, but increasing amounts of phosphoric acid. As in the previous questions, we have computed the yields in pounds per section in bushels per acre.

No. of Section.	Material Supplying Phosphoric Acid.	Ration.	Year.	Yield of Tubers in Bushels Per Acre. Total.	Large.	Small.
4	Dis. phosphate rock.	1	1896	302.26	198.00	104.26
4	Dis. phosphate rock..	1	1897	284.31	148.80	135.51
	Average..	..	......	**293.28**	**173.40**	**119.88**
6	Dis. phosphate rock..	2	1896	321.13	223.37	97.76
6	Dis. phosphate rock..	2	1897	292.66	155.30	137.36
	Average..........	...	......	**306.89**	**189.33**	**117.56**
7	Dis. phosphate rock..	3	1896	315.25	223.06	92.19
7	Dis. phosphate rock.	3	1897	280.29	150.97	129.32
	Average.........	...	.....	**297.77**	**187.01**	**110.75**

It will be seen from the above table, and by reference to tables I and III, where the weights of fertilizers used are given, that section 4 received one ration of phosphoric acid, section 6, two, and section 7 three rations. The yield was smallest, in 1896, upon

section 4, and largest upon section 6, where the double ration of phosphoric acid was used. The increase was 18.87 bushels in total crop, and 25.37 bushels of large potatoes. The yield of large potatoes upon section 7, where three rations of phosphoric acid were used, was almost identical with that upon section 6, but the total crop was 5.88 bushels less. In 1897 the increase in the crop of section 6 over section 4 was not as great as in 1896, and the total crop of section 7 was a little less than that upon section 4, but the yield of large potatoes was 2.17 bushels greater upon section 7. Averaging the yields of the two years we find that the one ration of phosphoric acid, section 4, has given the smallest average yield; three rations, section 7, occupies the second position in point of yield; and the two rations, section 6, produced the highest average yield—15.93 bushels of large potatoes more than section 4. It is an open question whether sections 6 and 7 had sufficient nitrogen to show the maximum benefit to be expected from the increased rations of phosphoric acid. If we turn to tables I and III, and examine the percentage composition of the fertilizers used, we find that, while each of the sections under consideration secured the same weight of nitrogen and potash, the percentage composition varied greatly, and, while the fertilizer for section 4 can, perhaps, be called well balanced, as the quantity of phosphoric acid was increased for sections 6 and 7, the percentage of nitrogen and potash was lowered. This was unavoidable, as any increase in the quantity of nitrogen or potash applied to sections 6 and 7, over what was applied to section 4, would have made it impossible to determine whether any increase in crop was due to increase of phosphoric acid or not. The question of what constitutes a properly balanced fertilizer ration for our various cultivated plants is one about which we should have more definite information, which can only come through the careful study of the feeding ability of different kinds of plants. Fertilizers for specific crops have, heretofore, been compounded by manufacturers upon the basis of the analysis of the crop itself. The aim has been to supply the nitrogen, potash and phosphoric

acid, in the proportions found in the plant, in sufficient quantity to grow a maximum crop, and, perhaps, allow a liberal margin to remain in the soil as non-recoverable by the plant. From the standpoint of analysis, a plant containing a high percentage of potash, like the turnip or potato, should be manured with a fertilizer rich in potash, but practical experience has demonstrated that superphosphates are the special fertilizers for the turnip crop, and in very many experiments no other ingredient has exercised so great an influence upon the growth of potatoes as soluble phosphoric acid. It promotes a rapid and full development of the root system, especially in the young plant, and thus gives it the ability to secure a larger supply of the other elements than would be possible with only few roots. It also promotes the formation of starch and hastens ripening—a point worthy of note when early potatoes are grown. It is doubtless true that many, if not all, plants, which show, by analysis, a large percentage of any one element, are so constituted that they have more than average power to secure that element from the soil, and a corresponding weaker power to secure other equally necessary elements, although used by them in much smaller quantities. In that way only can we explain the fact that the application of an element which forms only a small percentage of a plant may, as a rule, in all soils and locations, exercise so great an influence upon its growth as to be recognized as a specific fertilizer for that class of plants. Upon this subject we quote the following from Storer's Agriculture, Vol. II, page 469, where, in writing of the action of potash, he says: "In trials made of a variety of plants, and continued through long terms of years, Lawes and Gilbert found that potassic manures were more useful with clover, beans and peas, than with any other plants, though, as regards grain crops, it was noticed that potash was somewhat more useful for wheat than it was for barley."

This experience has been summed up by Gilbert in the following terms: "It is found," he says, "that easily assimilable nitrogenous manures have generally a very striking effect in increasing

the growth of grain crops, such as wheat, barley, and oats, although these grain crops contain comparatively little nitrogen, and take but little of it from the land. The leguminous crops, on the other hand, such as peas, beans, clover and others, although highly nitrogenized, are, by no means, characteristically benefited by the use of direct nitrogenous manures, such as ammonia salts, and nitrates, though nitrates act much more favorably than ammonia salts. It appears, indeed, that we may say: Use phosphates for turnips, potash for leguminous plants, and active nitrogen for grain."

Although the potato is classed as a "potash plant," because of its large percentage of potash, very liberal applications of that element have repeatedly been shown to be injurious rather than beneficial, while many instances could be cited of the marked beneficial effect of applications of soluble phosphoric acid.

Dried Blood Compared with Nitrate of Soda.—The fourth question considered in this experiment was the comparative effect, upon potatoes, of dried blood and nitrate of soda as sources of nitrogen. Sections 1, 3 and 4, give results relating to that subject. The ration of muriate of potash and dissolved phosphate rock was the same in each case, and these are, therefore, not considered here. The yields have been computed in bushels per acre.

No. of Section.	Source of Nitrogen.	Ration.	Year.	Yield of Tubers, in Bushels, per Acre.		
				Total.	Large.	Small.
1	Dried blood.. ... . Nitrate soda...... ...	½ ½	1896	289.26	209.75	79.51
1	Dried blood............ Nitrate soda..........	½ ½	1897	246.90	120.96	125.94
	Average....	......	......	268.08	165.35	102.72
3	Dried blood............	1	1896	299.78	211.61	88.17
3	Dried blood............	1	1897	260.80	127.46	133.34
	Average...........	......	.....	280.29	169.53	110.75
4	Nitrate soda...........	1	1896	302.26	198.00	104.26
4	Nitrate soda...........	1	1897	284.31	148.80	135.51
	Average...........	......	......	293.28	173.40	119.88

Considering first the crop of 1896, we find that the largest total yield was from the full ration of nitrate of soda on section 4. The smallest yield of large potatoes was from the same section. The full ration of dried blood, section 3, gave the largest yield of large tubers, which was 13.61 bushels more than was produced on section 4. When both forms of nitrogen were applied, half a ration of each, the total yield was smallest, but the yield of large tubers was only 1.86 bushels less than upon section 3, which gave the highest yield. In the crop of 1897 the largest total yield, and also the largest yield of merchantable tubers, was from section 4, where nitrate of soda was used. Dried blood, section 3, held the second place, but the yield of total crop was 23.51 bushels less, and the yield of large tubers was 21.34 bushels less, than was produced by section 4. Section 1, which received one-half a ration each of nitrate of soda and dried blood, gave the smallest yield, 37.41 bushels of total crop and 26.84 bushels of large potatoes *less* than

when a full ration of nitrate of soda was applied. The differences in yields were greater in 1897 than in 1896. If we average the two crops we find that section 4—the full ration of nitrate of soda —has given the best yield, dried blood, section 3, the second best, and the half ration of each ranks third and last in point of yield. The average yield from the full ration of nitrate of soda was 13 bushels in total crop, 3.87 bushels of large potatoes and 9.13 bushels of small potatoes more than the average produced by the full ration of dried blood. The percentage of small potatoes is larger, however, in the best average yield, viz.:

No. of Section.	SOURCE OF NITROGEN.	Ration.	Per cent. of Large Tubers.	Per cent. of Small Tubers.
1	Dried blood........................ Nitrate soda........................	½ ½	61.67	38.33
3	Dried blood........................	1	60.48	39.52
4	Nitrate soda........................	1	59.12	40.88

Practical experience has taught the growers of early potatoes to have the greater part of the nitrogen in their potato fertilizers in the form of nitrate of soda, depending upon its quick action to hasten the development of the crop. This practice is, undoubtedly, wise, although care should be exercised that too much nitrogen is not used, as excessive applications of nitrate of soda or nitrogen in other forms tend to produce a succulent, rank, overgrown top, especially liable to attacks of blight. When late potatoes are grown the use of some form of organic nitrogen, which through nitrification becomes available as the season progresses, may be even better than nitrate of soda for a considerable portion of the supply of nitrogen.

SUMMARY.

FORM OF POTASH.

In 1896, in connection with nitrate of soda and dissolved phosphate rock, sulfate of potash produced 32.29 bushels more large potatoes per acre than muriate of potash. Where the supply of potash was half sulfate and half muriate the yield of large potatoes was 26.6 greater than when the entire supply was in the form of muriate.

In 1897, a wet season, muriate of potash gave a total yield 30.01 bushels greater per acre than the sulfate, but only 15.77 bushels more of marketable potatoes, showing that the muriate gave a greater proportion of small potatoes.

The average of the two years shows that the largest total crop and the largest yield of large potatoes was produced when the supply of potash was half sulfate and half muriate. The yield from the muriate exceeded that from the sulfate by 1.29 bushels in total crop, but in yield of large tubers the sulfate exceeded the muriate by 8.26 bushels.

AMOUNT OF POTASH.

In 1896 the double ration of muriate of potash produced the larger yield, the increase being 3.70 bushels in total crop and 12.99 bushels of large potatoes per acre above that produced by the single ration.

In 1897 the results were reversed: the single ration produced a total crop 25.68 bushels per acre and 13.61 bushels of large potatoes per acre more than the double ration.

The average of both years' crops shows the greater yield of total product and both large and small potatoes to have been from the use of the single ration of muriate of potash.

INCREASING THE RATION OF PHOSPHORIC ACID.

In 1896, of three sections which received, respectively, one, two and three rations of phosphoric acid, the single ration gave

the lowest yield and the double ration the highest, or 18.87 bushels per acre in total crop and 25.37 bushels of large potatoes in excess of the yield from the single ration. Where three rations were used the yield of large tubers fell very little short of the highest yield, but the total crop was less than the highest by 5.88.

In 1897 the double ration exceeded the single ration by a yield of 8.35 bushels per acre in total crop and 6.50 bushels of large potatoes, while the three rations of phosphoric acid produced 4.02 bushels per acre of total crop *less*, and 2.17 bushels per acre of large potatoes *more*, than the single ration.

The average of the two years' crops shows that the single ration gave the smallest average yield, the three rations gave the next largest average yield, and the double ration produced the largest yield—15.93 bushels per acre of marketable potatoes more than was produced by the single ration. The double ration cost $6.29 more per acre, in 1897, than the single ration.

FORM OF NITROGEN.

In 1896 a full ration of nitrate of soda gave the largest total crop and the smallest yield of marketable potatoes. The full ration of dried blood gave a crop of large tubers 13.61 bushels per acre greater than the nitrate of soda application, and half a ration of each used together produced a yield of large tubers only 1.86 bushels less than the best yield.

In 1897 the full ration of nitrate of soda produced the largest crop. The full ration of dried blood and the half ration of each produced a considerably smaller yield—23.51 bushels per acre and 26.84 bushels per acre of large potatoes, respectively, *less* than the full ration of nitrate of soda.

The average of the two years shows that the crops rank as follows in respect to yields: 1st, nitrate of soda; 2d, dried blood; and 3d, the half ration of each; but the differences are not great in the average of the crops, the extremes in the marketable tubers being 165.35 and 173.40.

FURTHER TESTS OF SEED POTATOES GROWN ONE OR MORE YEARS IN RHODE ISLAND FROM NORTHERN GROWN SEED TUBERS.

CHAS. O. FLAGG AND J. A. TILLINGHAST.

In Bulletin No. 36 of this Station is given an account of work done in 1894 and 1895 in testing the value of northern grown seed potatoes in comparison with Rhode Island grown seed tubers of the same varieties. The record of the continuation of the work is found in the Annual Report of this Station for 1896, page 344. In 1897 no seed tubers from Aroostook Co., Maine, were used in the trial. The seed tubers used had all been grown upon the Station grounds for one, two and three years, respectively, from Maine grown seed tubers. The field used for the trial was the west end of "Field A," used for the same purpose in 1896, and the method of planting and fertilizing was also the same as far as possible. The land was plowed April 28th, with a sulky swivel plow, and the furrows leveled with a harrow. On May 5th fertilizer was applied broadcast, and the ground very thoroughly harrowed. The fertilizer used was made up as follows: Nitrate of soda, 105 pounds; tankage, 750 pounds; dissolved phosphate rock, 540 pounds; fine ground bone, 120 pounds; and muriate of potash, 300 pounds; making a total application of 1,815 pounds per acre. Only three-fourths of the total amount required for the area planted was applied broadcast, the remaining fourth being reserved for use in the drills at the time of planting. The furrows were carefully marked out across the plot, from east to west, with stakes and lines 30 inches apart and four or five inches deep.

The sets were placed exactly twelve inches apart, using a surveyor's 100-foot chain for the purpose of securing accuracy.

Beginning at the north end of the field, three rows of each variety were planted, and then the list was repeated, three rows more of each being planted. In each case the three rows represented the three classes of seed tubers, *i. e.*, those from which the second year, third year and fourth year crops were produced. There were, therefore, two rows of each class of seed, one on the north end and one on the south end of the plot. Seed tubers, of about the same average size as far as possible for all the varieties, were selected, ten pounds of each weighed out and cut, in each instance, into 150 sets of practically uniform size. Half of these sets were planted in the north row and half in the south row. After the sets were planted in the drills they were covered with a Planet, Jr. cultivator, and the ground leveled with a Breed's weeder.

May 17 the weeder was used to break the crust and lightly stir the surface soil. June 11th a horse cultivator was used between the drills, and on the 16th a hand-wheel cultivator. June 18th Paris green was applied, and on July 3d the last cultivation and hoeing was given, after which the vines were sprayed with Bordeaux mixture and Paris green. July 8th Paris green was used with a powder gun. Bordeaux mixture was applied with a spray pump July 15th, 19th, 26th, August 3d and 9th. The severity of the blight and the washing of the vines by frequent rains, which removed the coating of Bordeaux mixture almost as quickly as applied, rendered the spraying less efficient than usual. The potatoes were dug September 30th. The product of each drill was separately counted, assorted and weighed, but in compiling the following table the *average product* of the north and south drills is given in pounds and numbers of tubers. The average of the seven varieties, found in the line at the bottom of the table, best illustrates any variation due to influence of seed. In table II is given the average weight of the tubers and percentage of large tubers by weight and number.

TABLE I.

Showing the Average Yields, in Weights and Numbers of Tubers, from Two Drills each of Seven Varieties of Potatoes, the same being respectively two, three and four crops removed from Aroostook Co., Maine grown Seed Tubers.

NAME OF VARIETY.	Average Weight, in Pounds, of Tubers in North and South Rows.									Average Number of Tubers in North and South Rows.								
	Total.			Large.[4]			Small.			Total.			Large.[4]			Small.		
	2d[1] Year.	3d[2] Year.	4th[3] Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	4th Year.
Early Northern	58.87	51.62	49.50	33.62	27.50	32.75	25.02	24.12	17.25	583.0	490.5	417.0	187.5	158.5	179.0	345.5	332.0	238.0
Thorburn	60.50	57.00	56.25	37.87	34.12	28.75	22.62	22.87	27.50	498.5	496.0	570.5	206.5	179.0	164.5	292.0	317.0	406.0
King of the Early	58.00	57.87	59.00	34.15	34.62	36.87	23.62	23.25	22.12	586.0	518.5	512.0	198.0	175.5	204.5	388.0	338.0	307.5
Early Maine	56.12	59.50	59.00	28.90	34.25	35.25	27.00	25.25	23.75	581.0	551.0	536.5	164.5	190.0	201.0	416.5	361.0	335.5
White Star	62.12	60.25	57.50	39.87	33.87	38.87	22.25	26.62	18.62	485.0	482.0	421.5	198.5	177.5	206.0	286.5	304.5	215.5
Houlton Hebron	56.00	61.00	63.50	33.87	38.12	40.25	22.12	22.87	23.25	491.0	528.0	556.0	196.0	217.0	236.0	295.0	311 0	320.0
Burbank	60.00	58.00	60.75	37.62	37.00	39.50	22.37	21.00	21.25	477.5	468.0	458.0	190.5	193.0	199.0	287.0	271.0	259.0
Average	58.80	57.89	57.93	35.13	34.21	36.08	23.57	23.71	21.96	521.7	504.1	495.9	190.9	184.3	198.6	330.1	319.2	297.3

[1] Crop produced from seed tubers grown in Rhode Island from northern grown potatoes.
[2] Crop produced from seed tubers grown two years in Rhode Island from northern grown potatoes.
[3] Crop produced from seed tubers grown three years in Rhode Island from northern grown potatoes.
[4] All tubers two ounces or more in weight were classed as large.

TABLE II.

Showing the Average Weights of Tubers, and the Percentage of Large Potatoes in Crops Produced by Home grown Seed Tubers, derived from Potatoes grown in Aroostook Co., Maine.

VARIETY.	Average Weight of Tubers.									Per Cent of Large Tubers by Weight.					Per Cent. of Large Tubers by Numbers.				
	Total.			Large.			Small.			1897.[4]			1896.[5]		1897[4]			1896.[5]	
	2d[1] Year.	3d[2] Year.	4th[3] Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.	2d Year.	3d Year.	4th Year.	2d Year.	3d Year.
Early Northern	0.110	0.105	0.118	0.170	0.178	0.183	0.072	0.072	0.073	57.11	53.26	66.16	21.96	36.46	35.17	32.31	42.92	9.14	19.60
Thorburn	0.121	0.114	0.098	0.183	0.190	0.174	0.077	0.072	0.067	62.60	59.86	51.11	46.88	25.69	41.42	36.08	28.83	43.05	10.16
King of the Early	0.098	0.112	0.115	0.177	0.190	0.180	0.060	0.068	0.071	58.88	59.82	62.50	26.11	40.12	33.93	34.17	39.94	10.68	19.59
Early Maine	0.096	0.108	0.110	0.170	0.180	0.175	0.064	0.070	0.070	51.49	57.73	59.74	27.62	35.12	28.31	34.48	37.46	13.89	16.04
White Star	0.128	0.125	0.136	0.200	0.190	0.188	0.077	0.087	0.086	64.18	56.22	67.60	49.11	49.79	40.92	36.82	48.87	26.39	29.46
Houlton Hebron	0.114	0.115	0.114	0.172	0.175	0.170	0.075	0.073	0.072	60.49	63.50	63.38	48.77	41.82	39.91	41.09	42.44	25.64	21.37
Burbank	0.125	0.124	0.134	0.197	0.190	0.198	0.077	0.077	0.082	62.70	63.79	65.02	30.42	39.90	39.81	41.23	43.44	13.08	19.94
Average	0.113	0.114	0.113	0.181	0.184	0.181	0.072	0.074	0.074	59.63	59.02	62.21	35.84	36.41	36.92	36.59	40.55	20.25	19.45

[1] From seed tubers grown in Rhode Island from northern grown potatoes.
[2] From seed tubers grown two years in Rhode Island from northern grown potatoes.
[3] From seed tubers grown three years in Rhode Island from northern grown potatoes.
[4] All tubers two ounces or more in weight were classed as large.
[5] All tubers three ounces or more in weight were classed as large.

In the work of 1896, with northern and home grown seed potatoes, it was shown that the yield from Maine grown seed was less than that from home grown tubers when the total yield was considered, but the increase from the use of the home grown seed was wholly small potatoes. The northern seed, while producing a smaller *total crop*, produced a larger crop of *marketable tubers* than was produced by the home grown seed. That result was in accord with the accepted experience of our practical potato growers. It became of interest, then, to see whether repeated planting of the annual product of the original stock of seed tubers would, or would not, show a gradual decrease in vitality by a decrease in total crop, average size, or proportion of marketable potatoes. If we arrange the figures together which give the averages for the seven varieties of potatoes grown, the variations, which are slight, may be the better seen:

	2d year.	3d year.	4th year.
Average yield, total crop.....	58.80 lbs.	57.89 lbs.	57.98 lbs.
Average yield, large tubers ..	35.18 "	34.21 "	36.03 "
Average yield, small tubers ..	23.57 "	23.71 "	21.96 "

In total yield the second year crop was largest, exceeding the other two by a little less than a pound each. In yield of large tubers, however, the fourth year crop exceeds the others, with the second year crop holding the second place. A yield so nearly uniform in quantity, and especially one giving the largest quantity of marketable potatoes from the seed which had been home grown the longest, would not indicate any weakening of the vital power or constitution of the varieties. We will now look at the average weight of the tubers and the percentage of large potatoes:

	2d year.	3d year.	4th year.
Average weight of tubers, total crop.	0.113 lbs.	0.114 lbs.	0.118 lbs.
Average weight of large tubers........	0 181 "	0.184 "	0.181 "
Average weight of small tubers........	0.072 "	0.074 "	0.074 "
Per cent. of large tubers by weight....	59.63	59.02	62.21

The average weight of the tubers in the total crop was lowest in the case of the second year crop, and highest in the case of the

fourth year crop; the latter also showed the highest percentage of large potatoes. The third year crop, however, gave a slightly higher average weight of large tubers. As before, we do not find in these figures any evidence of degeneration in the seed used.

Thus far we have considered only the *average yields* of the seven varieties, in order to eliminate as far as possible any varietal peculiarities which might exist, but before leaving this subject it is well, perhaps, to compare the yields of the several varieties as given in table I, on page 376. Considering the total yield, we find that Houlton Hebron gave the best yields, the highest of all being 63.5 lbs., or at the rate of 245.87 bushels per acre, in the fourth year crop. The lowest yields were returned by Early Northern, and here we find the yields decreasing from the second year crop to the fourth year crop, which is the lowest yield of any variety—49.5 lbs., or at the rate of 191.66 bushels per acre. Houlton Hebron, Burbank, and King of the Early, gave larger yields in the fourth year crop than in either of the other crops, while Early Northern, Thorburn and White Star gave the largest yields in the second year crop and decreasing yields in the third and fourth years. Early Maine gave the largest yield in the third year crop, but the fourth year crop almost equalled it, and both exceeded that of the second year. Two of the three varieties which gave decreasing yields, the longer the seed was home-grown, stand at the foot of the list when arranged in order of total yield. Adding the second, third and fourth year crops of each variety, and calculating the yield to bushels per acre, we find the varieties stand in the following order:

TOTAL YIELD.		LARGE TUBERS.	
1. Houlton Hebron	232.96 bush.	1. Burbank	147.29 bush.
2. White Star	232.15 "	2. Houlton Hebron	144.86 "
3. Burbank	230.70 "	3. White Star	144.18 "
4. King of the Early	225.69 "	4. King of the Early	136.36 "
5. Early Maine	225.37 "	5. Thorburn	130.02 "
6. Thorburn	224.25 "	6. Early Maine	127.00 "
7. Early Northern	206.49 "	7. Early Northern	121.15 "

SUMMARY.

The average yields of seven varieties of potatoes, home-grown respectively two, three and 4 years from seed tubers produced in Aroostook Co., Maine, show great uniformity. The heaviest average total yield was in the second year crop, while the heaviest yield of large potatoes was in the fourth year crop.

The average weight of the tubers produced was lowest in the case of the second year crop and highest in the fourth year crop. The percentage of large tubers by weight was greatest in the case of the fourth year crop.

The variety producing the heaviest crop gave the greatest yield secured in the test as the product of the fourth year crop, viz.: 245.87 bushels per acre; and the variety which gave the lowest yield, 155.84 bushels per acre, produced the smallest yield of the test as the product of the fourth year crop.

Varieties which produced the larger yields gave increased crops the longer the seed tubers had been home-grown, while those which produced smaller crops gave decreasing yields the longer the seed had been home-grown.

VARIETY TEST OF POTATOES.

CHAS. O. FLAGG, G. M. TUCKER, IN 1896, AND J. A. TILLINGHAST IN 1897.

In 1896, of seed tubers, one pound of each of eleven new varieties of potatoes was procured for trial. These were selected as the most promising of the varieties recently put on the market. The south end of plot 43 was selected for planting them. Each pound of seed tubers was cut into eighteen pieces of as nearly uniform size and division of eyes as was possible. Potato fertilizer was used broadcast before planting. Furrows were marked out from east to west on the plot, three feet apart, and about four inches deep. The sets were placed in these drills 20 inches apart on May 5th, and covered with earth by hand. A hand cultivator was used May 28th and June 1st. On June 2nd the plants were hand hoed, cultivated on the 12th, 13th and 16th, and again hand hoed on the 18th. On the 26th the vines were dusted with Paris green, and the last cultivation was given on June 29th. Paris green was used on July 4th and 14th, and Bordeaux mixture was applied with a spring pump on the 11th, 20th, 21st, 23d, 28th and 31st. Notes were taken of the relative growth of the tops and time of blossoming. July 27th one-half of each variety was dug, the tops, total tubers and four largest tubers weighed, and a record made of the number of tubers. The potatoes upon the other half of the plot were not dug until September 2nd, when the tops of most of the varieties were fully matured, while some of them had dried away and almost disappeared. The notes taken regarding the growth of tops and the data secured at the two dates of digging have been combined in the following table I.

TABLE I.

Record of a Test of a Few New Varieties of Potatoes in 1896.

VARIETY.	No. of Plants in Bloom.			July 3d.		Record of Nine[1] Hills Dug July 27th.					Record of Nine[1] Hills Dug Sept. 2d.						
	June 24th.	June 26th.	July 3d.	Height in Inches of Tallest Plant.	Growth of Tops.	Per cent. of Green Tops.	Weight in Pounds of Tops.	Weight in Pounds of Tubers.	Weight in Pounds of Largest Four Tubers.	Total Number of Tubers.	Weight of Tops in Pounds.	Weight of Tubers in Pounds. Total.	Weight of Tubers in Pounds. Large.	Weight of Tubers in Pounds. Small.	Number of Tubers. Total.	Number of Tubers. Large.	Number of Tubers. Small.
Enormous	1	1	0	16	Uneven.	80	11.50	6.85	2.15	84	6.25	14.50	12.50	2.00	42	26	16
Great Divide	0	0	0	21	"	20	4.60	7.45	1.35	58	2.50	8.75	5.25	3.50	56	17	39
Maule's Thoroughbred	9	12	Full.	20	Even.	50	10.00	13.65	1.45	85	2.00	15.50	10.50	5.00	76	33	43
Saco Valley	0	0	0	18	"	90	15.50	9.05	1.15	91	5.25	16.50	11.00	5.50	87	35	52
Burpee's Early	3	8	Fair.	19	"	80	5.30	12.25	1.55	113	0.75	13.25	7.50	5.75	81	28	53
Carman, No. 3	0	0	0	21	"	40	8.45	4.50	1.25	41	2.25	7.50	4.50	3.00	42	14	28
Carman, No. 1	2	4	Full.	19	"	90	15.20	10.70	1.20	71	6.75	14.50	9.50	5.00	68	30	38
Brock's Chance	0	0	1	19	"	50	7.75	10.10	1.40	97	1.00	11.00	7.50	3.50	62	25	37
Moneymaker	0	0	3	17	Uneven.	80	8.05	5.25	1.10	63	1.25	7.00	2.75	4.25	52	10	42
Irish Daisy	0	0	0	17	"	70	11.00	4.55	0.75	79	1.75	8.50	4.00	4.50	67	16	51
Pride of the South	0	0	0	16	"	10	8.50	9.35	1.45	90	0.50	11.50	7.75	3.75	57	26	31

[1] From ½ pound of seed tubers.

A good idea of the relative maturity of the different varieties can be obtained by comparing the weight of tops and tubers dug in July with the weights of the same variety obtained in September. The largest four tubers were selected from those of each variety dug in July and weighed. The variety called Enormous, although the September yield was more than double that of July, produced four tubers which, at this early date, averaged more than half a pound each. In table II the yields of the crop dug September 2nd have been calculated into yields per acre, and the varieties arranged in the order of yield of large tubers, the highest yield being named first. The weight of the tops at the time of digging is also given, and varies a good deal as the varieties ripen very early, medium or late in the season.

TABLE II.

Showing Yields of a few New Varieties of Potatoes tested in 1896, calculated to Bushels Per Acre, from Crop dug September 2d.

VARIETY.	Weight of Tops in Pounds per Acre.	Bushels of Tubers per Acre.			July Yield compared with September Yield. Per cent.
		Total.	Large.	Small.	
Enormous	6,050	233.93	201.66	32.27	47.24
Saco Valley	5,080	266.20	177.46	88.74	54.84
Maule's Thoroughbred	1,936	250.06	169.40	80.66	88.06
Carman, No. 1	6,534	233.93	153.27	80.66	73.79
Pride of the South	484	185.54	125.03	60.51	81.56
Burpee's Early	726	213.76	121.00	92.76	92.45
Breck's Chance	968	177.46	121.00	56.46	91.81
Great Divide	2,420	141.16	84.70	56.46	85.16
Carman, No. 3	2,178	121.00	72.60	48.40	60.00
Irish Daisy	1,694	137.13	64.54	72.59	53.53
Moneymaker	1,210	112.93	44.70	68.23	75.00

The tops of Breck's Chance, Burpee's Early and Pride of the

South, for instance, weigh considerably less than 1,000 pounds per acre each in September, and it will be noticed that these varieties gave a high percentage of their September yield at the time of digging in July. In the last column of table II is given the proportion of the total yield of tubers in July, as compared with that of September. Burpee's Early, Breck's Chance, Maule's Thoroughbred, Great Divide and Pride of the South each produced tubers when dug in July which weighed over 80 per cent. of the crop produced by the same varieties in September. Maule's Thoroughbred gave the heaviest yield in July, and was in September only exceeded in total yield by Saco Valley, and in yield of large potatoes by Enormous and Saco Valley. Enormous heads the list in yield of large potatoes, producing at the rate of 201.66 bushels per acre, which is 24.2 bushels more than the next best yield, at the same time it produced a less quantity of small potatoes than any other variety. It is probably the latest variety of those tried, as it had the lowest per cent. of September crop in the July digging.

Trial of Varieties of Potatoes in 1897.

Five of the eleven varieties grown in 1896 were selected for further trial, and one pound each of ten additional varieties secured from various seed dealers. The varieties of potatoes were planted on the south part of the west end of field A, near the northern and home grown seed potato test, and the ground was prepared for planting and fertilized as stated on page 374. Planting was done on May 11th. In the case of the five varieties grown in 1896, five pounds of each variety of seed tubers were selected and cut into 75 sets, which were planted 12 inches apart in drills 30 inches apart. In the case of the new varieties, of which we had one pound of seed tubers in each instance, the cutting was as uniform as possible into 18 sets each, which were planted in drills 30 inches apart and 24 inches apart in the drills. The surface area for each plant was the same as in 1896, where

the sets were planted 36 by 20 inches apart. The sets were covered by hand 4 inches deep. On May 17th Breed's weeder was used to break the crust and destroy any germinating weed seeds. The hand cultivator was used between the rows on June 11th and 16th, and again on July 3d, when the rows were hand hoed. Paris green was applied on June 18th, July 3d and 8th, and the tops were sprayed with Bordeaux mixture July 3d, 15th, 19th, 23d, 26th, August 3d and 9th. September 1st a few straggling weeds were removed by hand from among the growth of tops. The potatoes were not dug until October 2d, when the tubers were counted, assorted and weighed. All tubers weighing two or more ounces were classed as "large," and the balance as "small." In the last three columns of table III the yields have been calculated to bushels per acre and the varieties arranged in the table in the order of the yield of large potatoes.

As in 1896, the late variety, Enormous, heads the list in total yield and marketable crop, none of the new varieties of 1897 equaling it in yield. Maule's Thoroughbred, among the 1896 varieties, holds the third place as it did the previous year, and but little behind the second in yield. This season Pride of the South gave the second best yield, while, in 1896, Saco Valley, fourth this season, held second place. Of the ten new varieties Joseph heads the list in the yield of marketable potatoes, although Vigorosa considerably exceeds it in total crop, and ranks second in yield of large potatoes. Hampton Beauty, third on the list, exactly equaled the variety Joseph in total crop, but gave just twice as many small potatoes, and, therefore, produced a smaller marketable crop.

The remaining seven varieties all fell below a yield of 100 bushels of marketable potatoes per acre, and the last on the list gave but about one-third as large a yield of marketable potatoes as the first named. The following notes of growth and appearance of tops were taken July 23rd, and the notes relating to the tubers at the time of digging, October 2nd.

TABLE III.

Showing Results of a Further Trial of Five Varieties of Potatoes Obtained in 1896, and a Test of Ten New Varieties Obtained in the Spring of 1897.

	Variety.		Numbers of Tubers Harvested. Total.	Numbers of Tubers Harvested. Large.	Numbers of Tubers Harvested. Small.	Yield of Tubers in Pounds. Total.	Yield of Tubers in Pounds. Large.	Yield of Tubers in Pounds. Small.	Yield of Tubers in Bushels Per Acre. Total.	Yield of Tubers in Bushels Per Acre. Large.	Yield of Tubers in Bushels Per Acre. Small.
New Varieties in 1896.	Enormous..	5 lbs. of seed tubers of each variety, cut into 75 sets, and planted 12x30 inches apart.	374	190	184	60.0	44.00	16.00	282.32	170.36	61.96
	Pride of the South....		373	169	204	48.0	33.00	15.00	185.85	127.77	58.08
	Maule's Thoroughbred		416	162	254	50.0	31.00	19.00	193.60	120.03	73.57
	Saco Valley....... ..		448	117	331	45.5	25.75	19.75	176.17	99.70	76.47
	Breck's Chance.......		567	133	434	48.0	22.00	26.00	185.85	85.18	100.67
New Varieties in 1897.	Joseph...............	1 lb. of seed tubers cut into 18 sets, and planted 30x24 inches apart.	118	60	58	19.50	16.50	3.00	157.30	133.10	24.20
	Vigorosa.......		184	72	112	24.25	15.50	8.75	195.61	125.03	70.58
	Hampton Beauty. ...		138	63	75	19.50	13.50	6.00	157.30	108.90	48.40
	Uncle Sam...........		92	52	40	13.00	10.25	2.75	104.86	82.85	22.01
	Banner...............		85	47	38	11.50	8.50	3.00	92.76	68.56	24.20
	Early Six Weeks......		135	41	94	13.50	8.00	5.50	108.90	64.53	44.37
	Rural New Y'rk'r,No.2		82	36	46	11.00	7.50	3.50	88.73	60.50	28.23
	Sir Walter Raleigh....		88	42	46	11.50	7.00	4.50	92.76	56.46	36.30
	Bovee.....		108	36	72	11.00	6.00	5.00	88.73	48 40	40.33
	New Ideal..		55	29	26	7.25	5.50	1.75	58.48	44.36	14.12

NEW VARIETIES, 1896.

Enormous.—Tops, thrifty growth, very little blight. Flowers white. Tubers white, oblong, flattened, large, fairly even in size and shape, eyes large and shallow. Heavy yield; late variety.

Pride of the South.—Rather light growth of tops, considerable blight. No flowers. Tubers dun-colored, round, even in size and shape. Eyes medium depth; good yield.

Maule's Thoroughbred.—Fair sized tops, thrifty, and quite free from blight. Flowers white. Tubers dun-colored, oblong, roundish, even in size and shape. Eyes medium depth; good yield.

Saco Valley.—Broad, heavy tops, no blight, evidently a strong grower. Flowers purple. Tubers dun-colored, long and flattened. Shallow eyes. Fair yield.

Breck's Chance.—Tops somewhat smaller and growth more slender than the average, also a little more affected by blight. Flowers white. Tubers white, round, flattened, with rather small, shallow eyes. Fair yield.

NEW VARIETIES, 1897.

Joseph.—Large, healthy growth of tops, free from blight. Flowers white. Tubers pinkish in color, round to oblong, flattened, even in size and shape, with comparatively few shallow eyes. This variety withstood blight longer than any other. Season medium.

Vigorosa.—A fair growth of medium sized tops, a little affected with blight. Flowers white. Tubers white, or pale flesh-colored, round to oblong, flattened, even in shape, with shallow eyes. Largest total yield, but large proportion of small potatoes, possibly due to effect of blight. Early variety.

Hampton Beauty.—Tops quite large, and of thrifty growth, very little blight. Flowers white. Tubers white, oblong, slightly flattened, with large, shallow eyes, and of fairly even size and shape.

Uncle Sam.—Tops slightly larger than the average, thrifty growth, free from blight. Flowers white. Tubers white, roundish to long, with shallow eyes. Fair in shape and yield.

Banner.—Tops small, not a vigorous grower. A little affected with blight. Flowers purple. Tubers white, with russet skin, round to oblong and flattened, not large, but of even size and shape. Eyes few in number and shallow. Medium yield.

Early Six Weeks.—Rather low, stocky tops, of fair growth, but somewhat affected with blight. Flowers white. Tubers white, round, flattened, with shallow eyes. Fairly even in size and shape. Medium yield. Early variety.

Rural New Yorker, No. 2.—Small, rather stocky tops, but little affected with blight. Flowers purple. Tubers white, round, flattened, with small, shallow eyes. Fairly even in size and shape.

Sir Walter Raleigh.—Tops of medium growth and hardy in appearance. Free from blight. Flowers purple. Tubers white, oblong, flattened, with shallow eyes, and even in size and shape.

Bovee.—Fairly good growth of tops of medium height. Quite free from blight. Flowers white. Tubers whitish, oblong, uneven in shape, with deep set eyes. Inferior yield.

New Ideal.—Tops of medium size, healthy growth, but light in color. No blight. Flowers purple. Tubers red, oblong, flattened, with eyes of medium depth. Fairly even in shape and size. Small yield, but relatively large proportion of marketable potatoes.

THE POTATO CROP IN THE ROTATIONS.

CHAS. O. FLAGG, G. M. TUCKER, AND J. A. TILLINGHAST.

In connection with the potato experiment we wish to present a summary of the yields of potatoes in the rotations in progress. The plots from which the calculations are made are of one-tenth acre each in area (full size two-fifteenths acre). There are six separate rotations (see sixth annual report, 1893, pages 184 to 189), each of which includes the potato crop, so that there are six plots planted to potatoes each year. The fertilizer used for potatoes is the same in all cases; three-fourths of it is applied broadcast and well harrowed into the soil, and the other fourth is strewn in the furrows and mixed with the soil before the sets are dropped. The fertilizer used in 1897 was made up as follows, the quantity named being the amount used per acre: nitrate of soda, 105 pounds; tankage, 750 pounds; dissolved phosphate rock, 540 pounds; fine ground bone, 120 pounds; muriate potash, 300 pounds; total, 1,815 pounds. When potatoes follow clover, as in rotations A and C, the sod is turned early in the spring and the ground very thoroughly harrowed. The soil is a sandy loam. The agricultural soil is shallow but gradually being deepened, hence the plowing for potatoes is always as deep as possible without turning up too much subsoil. In rotations B, D, E and F, potatoes follow corn, and the ground is fitted for planting by thorough plowing and harrowing. Drills were marked out, with a furrowing plow, exactly three feet apart and five or more inches deep. The fertilizer reserved for the purpose was evenly strewn along the furrows, and the sets, cut so as to approximate two ounces

each in weight, were dropped exactly 12 inches apart. Each rotation plot had, in this way, exactly the same number of sets planted upon it. Covering of the sets was done with a Planet Jr. cultivator, which left about 4 inches of earth over them. The after cultivation was as follows in 1897: Breed's weeder was run over the plots on May 5th, 17th and 22d. A cultivator was used between the rows on the 27th and June 3d, when the drills were hand hoed. A weeder or cultivator was run between the drills on June 11th, 16th and 23d, and a hand hoe was used along the drills on June 18th and July 3d. Paris green was applied three times, and Bordeaux mixture five times, at intervals, to protect the tops from potato bugs and blight. The variety planted in both years was "Queen." The crops produced have been at the following rates per acre:

TABLE I.

Yields of Potatoes on Rotation Plots in 1896 and 1897. Variety, "Queen."

	Rotation.	Year.	Number of Plot.	Yields of Tubers in Bushels Per Acre.		
				Total.	Large.	Small.
	A	1896	5	297.66	195.16*	102.50
	A	1897	3	323.32	231.66	91.66
Average.........	.....	....	......	**310.49**	**213.41**	**97.08**
	B	1896	10	277.00	222.17	54 83
	B	1897	8	210.00	190.83	99.17
Average.........	.....	....	.....	**243.50**	**206.50**	**77.00**
	C	1896	11	282.16	233.33	48.83
	C	1897	14	274.83	192.83	82.00
Average.........	.. ..	....	......	**278.49**	**213.08**	**65.41**
	D	1896	22	267.16	215.50	51.66
	D	1897	20	267.84	211.67	56.17
Average.	.....	....	.....	**267.50**	**213.58**	**53.91**
	E	1896	32	253.33	210.50	42.83
	E	1887	30	241.91	183.33	58.58
Average.........	.....	....	......	**247.62**	**196.91**	**50.70**
	F	1896	37	258.16	227.50	30.66
	F	1897	35	303.58	232.50	71.08
Average.........	.....	.. ..	......	**280.87**	**230.00**	**50.87**

* Includes 60.5 bushels so worm-eaten as to be unsalable.

We find from this table of yields that the best total crop from the 12 plots, in two years, was 323.32 bushels per acre from plot 3 in rotation A, in 1897, and that the poorest yield was from plot 8, rotation B, in 1897—210 bushels per acre.

The *best* four yields of large[1] potatoes from the 12 plots, in two years, were as follows :

238.33	bushels	per acre	from	plot	11,	Rotation	C,	in	1896.
232.50	"	"	"	"	35,	"	F,	"	1897.
231.66	"	"	"	"	3,	"	A,	"	"
227.50	"	"	"	"	37,	"	F,	"	1896.

The *poorest* four yields of large[1] potatoes from the 12 plots, in two years, were as follows:

183.33	bushels	per acre	from	plot	30,	Rotation	E,	in	1897.
190.83	"	"	"	"	8,	"	B,	"	"
192.83	"	"	"	"	14,	"	C,	"	"
195.16	"	"	"	"	5,	"	A,	"	1896.

The last named yield included 60.5 bushels so worm-eaten as to be unsalable. All other yields, in the two years, have exceeded 200 bushels per acre of merchantable tubers. The average yield per acre of the six rotations, in 1896, was as follows: Large,[1] 217.36 bushels; small, 55.22 bushels; total, 272.58 bushels. The corresponding average yield, in 1897, was as follows: Large,[1] 207.14 bushels; small, 76.44 bushels; total, 283.58 bushels. One point worthy of note in this connection is the yields of potatoes in rotations A and C, when they are planted upon a clover sod, as compared with the yields in the other four rotations in which they follow the corn crop. Taking from table I the average yields of the rotations we have the following :

[1] Tubers weighing 2 ounces or more in weight.

Average Yields of Rotations in Bushels Per Acre.

	Rotation.	Total.	Large.	Small.
Potatoes planted on clover sod	A	310.49	218.41	97.08
	C	278.49	218.08	65.41
Average	....	**294.49**	**218.24**	**81.24**
Potatoes planted after corn crop	B	243.50	206.50	77.00
	D	267.50	213.58	53.91
	E	247 62	196.91	50.70
	F	280.37	230.00	50.87
Average	....	**259.74**	**211.74**	**56.62**

From the above it is evident that when potatoes have been planted on a clover sod the average yield has exceeded that obtained when potatoes had followed the corn crop. The growth of tops upon the clover sod plots was very rapid and vigorous, indicating the presence in the soil of considerable available nitrogen.

TRIAL OF PHOSPHATES.

CHAS. O. FLAGG AND J. A. TILLINGHAST.

In the annual report of this Station for 1896, pages 327 to 343, may be found a full account of the plan of this experiment, which was begun in 1894, and the results obtained up to the close of that year.

The purpose of this experiment is to determine, if possible, which of the several forms of phosphoric acid, all things considered, is most economical; hence, *like money values* have been used, giving to all the plots like conditions of cultivation, cropping, etc.

This experiment occupies plots 51 to 70, inclusive, each two-fifteenths of an acre in area, but all calculations are based on the interior one-tenth acre in each case. They are arranged in two rows, the odd numbered plots on the north, and the even numbered plots on the south of a drive-way. To the ten plots on the north air-slacked lime was applied, in 1894, at the rate of one ton per acre, while those upon the south side have never been limed. All plots have received like amounts of potash and nitrogen,[1] and, excepting the pair of check plots 67 and 68, practically the *same money value of phosphoric acid.* Plots 69 and 70 were not included in the experiment the first year, *i. e.*, 1894, but since then the treatment has been as stated. Each pair of plots has received

[1] In this experiment no account is taken of the nitrogen contained in fine ground bone and dissolved bone. The price of these materials is influenced by the amount of nitrogen as well as phosphoric acid which they contain, and, as the experiment is on a basis of *money value*, the benefit of the extra nitrogen, if any, is allowed to count in favor of the bone.

its supply of phosphoric acid in a form different from the others, therefore, nine different sources of phosphoric acid have been compared. Two plots were devoted to each form of phosphoric acid, one limed and the other unlimed, because of the previously observed marked good effect of applications of air-slacked lime upon our soil, and the quite different effect of fertilizers when applied with it as compared with their effect without it. The plots were seeded to grass in the fall of 1895. It was decided to apply the fertilizers in the most rational way, and, as the so-called *insoluble* phosphates are thought to be but slowly available in the soil, what was called a full ration was applied to their respective plots at the time of seeding to grass. No other fertilizing material was applied to any of the plots at the time of seeding. Each of three succeeding springtimes, however, *all the plots* receive a one-third ration of nitrate of soda and potash, while at the same time a one-third ration of the soluble phosphates is applied to the plots designed to receive these forms. At the end of three years, therefore, all the plots will have received a like money value of fertilizer, excepting, of course, the pair of check plots and ten plots to which the lime was applied at the beginning of the experiment. The cost, at ton rates, of the phosphates per plot and per acre, the analyses of the materials used as a source of soluble phosphoric acid and applied as top-dressing, May 15th, 1897, are given in the following table I:

TABLE I.

Analyses of Materials Used to Supply Phosphoric Acid, Applied as Top-Dressing, in the Spring of 1897.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	Cost per ton delivered at Kingston.	Pounds per plot.[1]	Pounds per acre.	ANALYSES.				
				PHOSPHORIC ACID.				Per cent. nitrogen.
				Per cent. soluble.	Per cent. reverted.	Per cent. insoluble.	Total percentage.	
Dissolved boneblack	$18.00	26.66	200.0	12.64	2 26	.32	15.22	
Dissolved bone...	24.00	20.00	150.0	3.23	10.24	4.59	18.06	3.27
Dissolved phosphate rock.	14.40	34.25	257.0	11.42	3.50	1.22	16.14	
Double superphosphate	44.00	10.90[2]	81 8	48 76		.60	49.36	

The money value of the application of phosphoric acid was at the rate of $1.80 per acre, of the muriate of potash, $1.60, and the nitrate of soda, $2.74, or a total of $6.14 per acre. In the case of the insoluble phosphates, fine ground bone, slag meal, floats, raw alumina phosphate and ignited alumina phosphate, a full ration having been applied, in the fall of 1895, at the time of seeding to grass, only nitrate of soda and muriate of potash were used as top-dressing on those plots, at a total cost of $4.34 per acre.

The plots were all well rolled, April 8th, with an iron roller, to

[1] At the time, May 15th, when the above one-third ration of soluble phosphates was applied to four pairs of plots respectively, each of the twenty plots in the experiment received as top-dressing, nitrate of soda, at the rate of 133.66 pounds per acre, and muriate of potash at the rate of 80. pounds per acre, as in the spring of 1896.

[2] In 1896 only a small quantity of double superphosphate was purchased, at a cost of three cents per pound, which was far above ton rates. In consequence, only 8 pounds were applied instead of 10.9 pounds, as published in the Annual Report for 1896, page 336. In top-dressing, in 1897, this shortage was rectified by the addition of 2.9 pounds, the amount of the shortage last year, therefore, the actual application has been as follows: In the spring of 1896, 8 pounds; in the spring of 1897, 13.8 pounds; total, 21.8 pounds, or an average of 10.9 pounds, as published in the tables.

compact the earth about the grass roots after the action of the winter frosts. Occasional ox-eye daisy (*Leucanthemum vulgare*) plants or other noxious weeds were removed by hand, from May 27th to June 8th, inclusive. Owing to the protracted wet weather haying was delayed a little, and the grass was not cut for hay until July 15th, when all the plots were cut the same day, and the notes in table II regarding the crop taken. It may be of interest to repeat here the statement from the annual report of 1896 relating to the kinds and quantities of grass seed used in seeding in 1895. The rate given is per acre:

Timothy (*Phleum pratense, L.*).......	16.87	pounds	(12 quarts).
Redtop (*Agrostis vulgaris, L.*)........	6.00	"	cleaned seed.
Red clover (*Trifolium pratense, L.*)...	12.00	"	

The reader will bear in mind that the same weight and mixture of seed was used upon each plot, and the differences in the character of the crop must be reasonably attributed to the influence of the lime and the phosphatic fertilizer.

TABLE II.

First Crop of Hay Trial of Phosphates, 1897.

Materials Used to Supply Phosphoric Acid.	No. of Plots. Limed.[1]	No. of Plots. Unlimed.	Notes Taken July 15th.	Pounds of hay per plot. 1st cutting.
Dissolved boneblack	51	....	Timothy and clover in nearly equal quantities; a little redtop	570
	....	52	Redtop and some Timothy	252
Dissolved bone	53	....	Timothy and clover; more redtop than No. 51	560
	....	54	Redtop; trace of Timothy	265
Dissolved phosphate rock	55	....	Considerable clover, Timothy and some redtop	570
	....	56	Redtop; trace of clover	260
Fine ground bone	57	....	Clover and Timothy; some redtop	600
	....	58	Redtop; a little clover	230
Slag meal	59	....	Timothy, clover and some redtop	580
	....	60	Redtop, considerable Timothy and some clover	360
Floats	61	....	Timothy, clover and considerable redtop	620
	....	62	Redtop, some Timothy and clover	270
Raw alumina phosphate	63	....	Some clover, redtop and Timothy	440
	....	64	Nearly pure redtop; trace of Timothy	175
Ignited alumina phosphate	65	....	Timothy, clover and redtop	440
	....	66	Pure redtop	172.5
No phosphoric acid	67	....	Clover and more redtop than Timothy	490
	....	68	Redtop; rather light growth, with trace of other grasses	80
Double superphosphate	69	....	Clover, Timothy and less redtop than No. 67	550
	....	70	Redtop, a few plants of Timothy, and some other grasses and weeds	185

[1] One ton of air-slaked lime per acre applied in 1894.

Phosphate Experiment, 1st Crop Hay, 1897. Unlimed plots.

Phosphate Experiment, 1st Crop Hay, 1897. Limed plots.

Phosphate Experiment, 2d Crop Hay, 1897. Unlimed plots.

Phosphate Experiment, 2d Crop Hay, 1897. Limed plots.

Any accurate determination of the exact proportion of timothy, redtop and clover, upon the various plots, was hardly possible, and the notes in the table are the result of careful observation and estimate. They serve to show the preponderance or absence of any one or more of the varieties upon the several plots. The reader will notice that the crop upon the *limed* or odd numbered plots consisted largely of timothy and clover with some redtop. Upon plots 63 and 67, however, the redtop appeared to equal or exceed the growth of timothy. Turning to the unlimed plots we find that there was little besides redtop upon most of them. The fine ground bone plot showed a little clover mixed with the redtop, and floats gave a crop with some intermixture of timothy as well as clover, but slag meal produced the best mixture of grasses and clover and the largest crop cut from any of the unlimed plots. On account of the wet summer there was an unusually large growth of grass following the first crop, and on September 3d a second crop was cut from all the plots. On the limed plots this second crop varied from 1,350 pounds to 2,025 pounds of hay per acre, but upon the unlimed plots the heaviest yield was only 324.4 pounds per acre and the lightest 37.5 pounds—much too small a yield to pay for cutting, except in an experimental way. In table III is given the weights of the first and second crops, separately, the total yield, the gain or loss of the limed plots over plot 67, which shows the effect of the various phosphates when used with lime, the same comparison with plot 68 in the unlimed series, and the gain in pounds of hay per acre through the use of lime.

TABLE III.

Showing the Results from the Use of Various Kinds of Phosphates, in Quantities Having an Equal Money Value, Both With and Without Lime, Upon Grass, in 1897.

MATERIALS USED TO SUPPLY PHOSPHORIC ACID.[4]	LIMED.[1]					UNLIMED.					Increase due to liming; Pounds of hay per acre.
	No. of plot.	Pounds of hay per plot.			Lbs. per plot gain (+) or loss (—) compared with plot 67.	No. of Plot.	Pounds of hay per plot.			Lbs. per plot gain (+) or loss (—) compared with plot 68.	
		1st crop.	2d crop.	Total.			1st crop.	2d crop.	Total.		
[2]Dissolved boneblack	51	570	195.00	765.00	+68.75	52	252.0	29.44	281.44	+197.69	4,835.6
[2]Dissolved bone	53	560	165.00	725.00	+28.75	54	265.0	17.06	282.06	+198.31	4,429.4
[2]Dissolved phosphate rock	55	570	195.00	765.00	+68.75	56	260.0	13.88	273.88	+190.13	4,911.2
[3]Fine ground bone	57	600	135.00	735.00	+38.75	58	230.0	8.63	238.63	+154.88	4,963.7
[3]Slag meal	59	580	138.75	718.75	+22.50	60	360.0	32.44	392.44	+308.69	3,263.1
[3]Floats	61	620	202.50	822.50	+126.25	62	270.0	13 50	283.50	+199.75	5,390.0
[4]Raw alumina phosphate	63	440	176.25	616.25	—53.00	64	175.0	3.75	178.75	+95.00	4,375.0
[4]Ignited alumina phosphate	65	595	198.75	793.75	+97.50	66	172 5	4.50	177.00	+93.25	6,167.5
No phosphoric acid	67	490	206.25	696 25	......	68	80.0	3.75	83.75	......	6,125.0
[2]Double superphosphate	69	550	191.25	741.25	+45.00	70	135.0	10.88	145.88	+62.13	5,953.7

[1] One ton of air-slaked lime per acre was applied in 1894.
[2] A one third ration of these phosphates is applied as top-dressing each spring for three successive years.
[3] A full ration of these phosphates was applied in the fall of 1895, when the plots were seeded to grass.
[4] Each plot in the experiment received a top-dressing, May 15th, of nitrate of soda, at the rate of 133.66 pounds per acre, and of muriate of potash at the rate of 80 pounds per acre.

In considering the yields from the various plots in 1897, we will first look at that from plot 68, in the *unlimed* series, which received no phosphoric acid. This tenth-acre plot yielded only 83.75 pounds of hay, or 837.5 pounds per acre—a very light and unprofitable crop. The top-dressing of nitrate of soda and muriate of potash used on this plot cost at the rate of $4.34 per acre, and the hay, if sold for $14 per ton—a good price when weighed directly out of the field—would bring only $5.86, which, less the cost of top-dressing, would leave $1.52 to pay for cutting, curing and marketing. Is not this a forcible illustration of the fact that the use of fertilizers under certain conditions does not pay? The addition of phosphoric acid to the fertilizer increased the yield in every instance in the unlimed series. The lowest yield was where the double superphosphate was applied, plot 70, and was almost twice that above mentioned from plot 68. The largest yield was from plot 60, which received *slag meal*, and lacked but a few pounds of two tons per acre. The next best yield was from the application of *floats*, plot 62, and was at the rate of 2,835 pounds per acre. Dissolved bone, plot 54, and dissolved boneblack, plot 52, also produced at the rate of over 2,800 pounds per acre. Dissolved phosphate rock and fine ground bone, plots 56 and 58, come next in order, and conclude the list of those on the unlimed series which produced at the rate of more than one ton per acre. The two alumina phosphates produced at the rate of a little over 1,700 pounds per acre, and the double superphosphates, before mentioned, only 1,458.8 pounds per acre. Considering the quantity of fertilizer which has been applied, these crops average below what the farmer ought to realize, and serve to show that the application of a so-called well balanced, complete fertilizer, containing a sufficient amount of nitrogen, potash and phosphoric acid, can not always be depended upon to give sufficiently remunerative results.

Let us now compare the crops produced by the *limed* series of plots. These plots received at the beginning of the experiment, in 1894, one ton of air-slacked lime (costing now $6.00 to $8.00 per ton) per acre, otherwise, they have been treated, in all respects,

the same as the unlimed series. The check plot in this series was 67, which received no phosphoric acid, and the yield of hay was 696.25 pounds, or at the rate of almost 3½ tons per acre. This yield was 8.31 times as large as that upon the check plot 68, in the unlimed series, and, if figured at the same price (it was really hay of better quality), would be worth $48.73, which, less the cost of top-dressing, $4.34, as in the case of plot 68, leaves $44.39 to pay for cutting, harvesting and marketing, as against $1.52 in the case of plot 68. This difference may be fairly attributed to the influence of the lime applied in 1894. Of course the production of such heavy crops upon plot 67, without the application of any phosphoric acid, will, doubtless, quickly exhaust the supply of available phosphoric acid in the soil, and then the plot will become more or less unproductive, while, at any time, if plot 68 were to be plowed, dressed with one ton of air-slacked lime per acre well worked into the soil, and seeded to grass, it would, undoubtedly, produce as good crops as has plot 67, until such time as its supply of available phosphoric acid should be exhausted.

The large yield of hay upon plot 67, without phosphoric acid, left comparatively little room for improvement through the addition of that element to the fertilizer, yet we find an increase in the crop, due to the application of phosphoric acid, in every instance, with the one exception of raw alumina phosphate, plot 63, where the yield of hay was about one-fourth of a ton per acre less than that of plot 67, where no phosphoric acid was applied. In 1896 the yield of this plot was just half a ton less than that of plot 67, and, as this year, it was the only plot in the limed series where the yield fell below that of plot 67.

The largest yield came from plot 61 where *floats* was applied, and amounted to 8,225 pounds per acre in both cuttings, or over four tons. Seven (7) of the remaining eight phosphates produced crops at the rate of over 3½ and less than 4 tons per acre this season. Their yields place them in the following order; the figures give pounds of hay per acre: Ignited alumina phosphate, 7,937.5 pounds; dissolved boneblack and dissolved phosphate

rock, each 7,650 pounds; double superphosphate, 7,412.5 pounds; fine ground bone, 7,350 pounds; dissolved bone, 7,250 pounds; and slag meal, 7,187.5 pounds. As above stated, the yield from plot 67, without phosphoric acid, almost reached the 3½ ton mark, viz.: 6,962.5 pounds per acre; consequently the column of "gain or loss over plot 67" shows comparatively small gains through the use of phosphoric acid, the largest being in the case of floats, 1,262.5 pounds per acre, and the smallest 225 pounds, in the case of slag meal. In the unlimed series the column of "gain or loss over plot 68" shows much larger gains through the use of phosphoric acid. The largest gain in this series was made by slag meal, and was at the rate of 3,086.9 pounds per acre, or over 1½ tons. No other form of phosphoric acid gave a gain of one ton per acre, although floats lacked only 25 pounds of it, and three others, dissolved bone, dissolved boneblack and dissolved phosphate rock, gave a gain of over 1,900 pounds each. The reason that slag meal so far outstripped the others in this series is due, probably, to the fact that it contains about 50 per cent. of lime, apparently so essential to the successful growth of many plants upon our soil.

In the last column of table III is given the increase in the crop in pounds of hay per acre, due to liming, and fully illustrates the great difference in yield of hay between the limed and unlimed plots of each pair in the experiment. The smallest difference, as would be expected from the comparatively large yield of plot 60, in the unlimed series, is in the case of the slag meal, and is at the rate of 3,263.1 pounds of hay per acre—over 1½ tons, and enough in one season to about *three times* pay the cost of the lime applied, the benefit of which, however, is extended over several years—we cannot yet say how many. In the case of all the other plots the benefit from liming is shown by an increase in crop of 2 to 3 tons per acre, and in two instances the increase exceeded 3 tons per acre. Of the latter, one was the pair of plots which received no phosphoric acid, and the other was the pair to which ignited alumina phosphate was applied. This phosphate, in the limed series plot 65, made the second best yield in the series, but on the

other hand, without lime plot 66, it produced *less than any other form of phosphoric acid.* The raw alumina phosphate, however. was but a trifle above it in yield when unlimed, and in the limed series *produced less than any other form of phosphoric acid,* and even less than the check plot which received no phosphoric acid.

In table IV we have taken from the annual report of 1896 the yields of hay for that year, and compiled them with the results of 1897, so as to present the total hay crop of the two years, and show the gain or loss in each series as compared with the yields from plots 67 and 68, the ratio of the yields from the various plots compared with the check plots, and the total increase for the two years stated in pounds of hay per acre.

We cannot, of course, form at this time any conclusive opinions regarding the actual efficiency of the phosphates under trial, because of the fact that the plots receiving the *soluble* phosphates have yet to receive, in the spring of 1898, a top-dressing of phosphoric acid, one-third ration, to complete the three annual top-dressings and place them upon the same footing with the *insoluble* phosphates which were applied as a full ration at the time of seeding in the autumn of 1895. We have, however, ventured to arrange them in order of yield of hay produced in 1896 and 1897, in table V.

TABLE IV.

Showing Total Yields of Hay for 1896 and 1897, with Gain or Loss Compared with Yields from Plots 67 and 68, and Ratio of Yields.

Materials Used to Supply Phosphoric Acid.	Limed.						Unlimed.						
	No. of plot.	Pounds of hay per plot. Crop of 1896. 1 cutting.	Crop of 1897. 2 cuttings.	Total for 1896 & 1897.	Total lbs. per plot gain (+) or loss (—) compared with plot 67.	Ratio of yield to that of plot 67 as 1.	No. of plot.	Pounds of hay per plot. Crop of 1896. 1 cutting.	Crop of 1897. 2 cuttings.	Total for 1896 & 1897.	Total lbs per plot gain (+) or loss (—) compared with plot 68.	Ratio of yield to that of plot 68 as 1.	Increase in two years due to liming. Pounds of hay per acre.
Dissolved boneblack........	51	380	765.00	1,145.00	+368.75	1.47	52	80	281.44	361.44	+277.69	4.31	7,835.6
Dissolved bone.............	53	210	725.00	935.00	+158.75	1.20	54	25	282.06	307.06	+223.31	3.66	6,279.4
Dissolved phosphate rock...	55	353	765.00	1,118.00	+341.75	1.44	56	80	273.88	353.88	+270.13	4.22	7,641.2
Fine ground bone.	57	545	735 00	1,280.00	+503.75	1.64	58	445	238.63	683.63	+599.88	8.16	5,963.7
Slag meal......	59	500	718.75	1,218.75	+442.50	1.57	60	400	392.44	792.44	+708.69	9.46	4,263.1
Floats.......	61	335	822.50	1,157.50	+381.25	1 49	62	265	283.50	548.50	+464.75	6.54	6,090 0
Raw alumina phosphate.....	63	70	616.25	686.25	—90.00	.88	64	00	178 75	178.75	+95.00	2.18	5,075.0
Ignited alumina phosphate..	65	240	793.75	1,033.75	+257.50	1.33	66	00	177.00	177.00	+93.25	2.11	8,567.5
No phosphoric acid.........	67	80	696.25	776.25	......	1.00	68	00	83 75	83.75	... ..	1.00	6,925.0
Double superphosphate.....	69	175	741 25	916 25	+140.00	1.18	70	00	145 88	145.88	+62.13	1.74	7,703.7

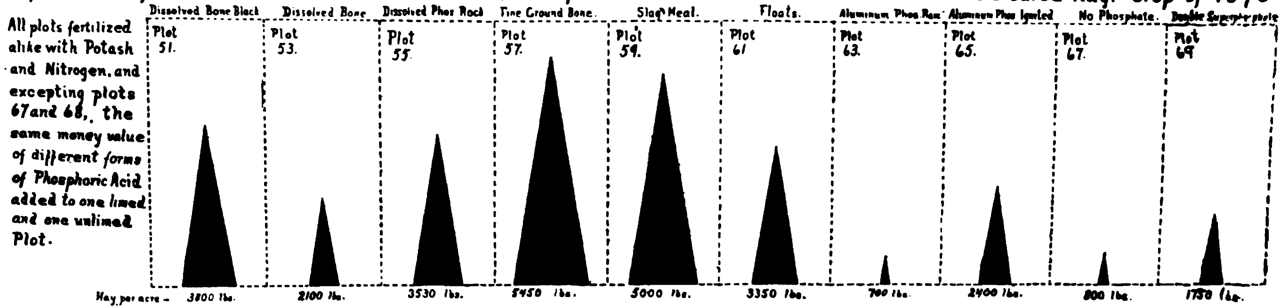
TABLE V.

Showing the Materials Used to Supply Phosphoric Acid, Arranged in Order of Yields of Hay, in the Years 1896 and 1897.

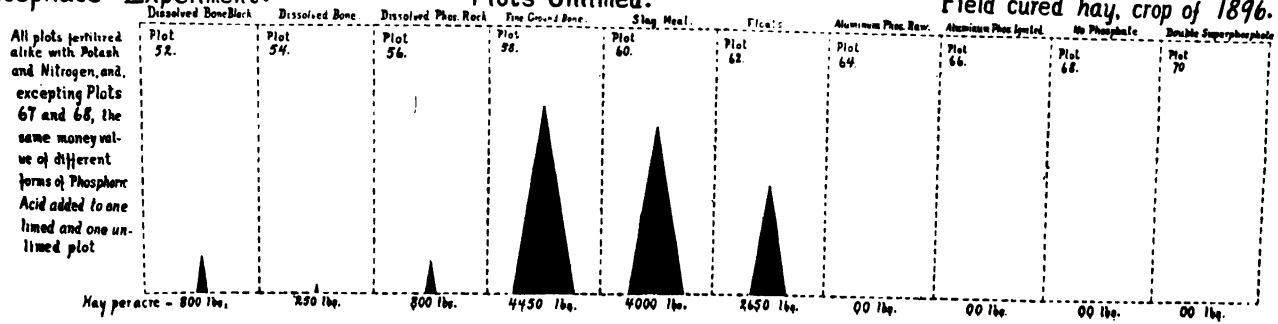
MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	LIMED.			MATERIALS USED TO SUPPLY PHOSPHORIC ACID.	UNLIMED.		
	No. of Plot.	Total pounds of hay per plot, 1896 & 1897.	Ratio of yields to that of plot 67 as 1.		No. of Plot.	Total pounds of hay per plot, 1896 & 1897.	Ratio of yields to that of plot 68 as 1.
Fine ground bone	57	1,280.00	1.64	Slag meal	60	792.44	9.46
Slag meal	59	1,218.75	1.57	Fine ground bone	58	683.63	8.16
Floats	61	1,157.50	1 49	Floats	62	548.50	6.54
Dissolved boneblack	51	1,145.00	1 47	Dissolved boneblack	52	361.44	4.31
Dissolved phosphate rock	55	1,118 00	1.44	Dissolved phosphate rock	56	353 88	4.22
Ignited alumina phosphate	65	1,033.75	1 33	Dissolved bone	54	307.06	3.66
Dissolved bone	53	935.00	1.20	Raw alumina phosphate	64	178.75	2.13
Double superphosphate	69	916.25	1.18	Ignited alumina phosphate	66	177.00	2.11
No phosphoric acid	67	776.25	1.00	Double superphosphate	70	145.88	1.74
Raw alumina phosphate	63	686.25	0.88	No phosphoric acid	68	83.75	1.00

NOTE.—The yield of plot 67, used as the unit of the column of ratios in the *limed* series, is 9.26 times as great as the yield from plot 68, which is used as the unit of the column of ratios in the *unlimed* series. The columns of ratios should not, therefore, be compared one with the other.

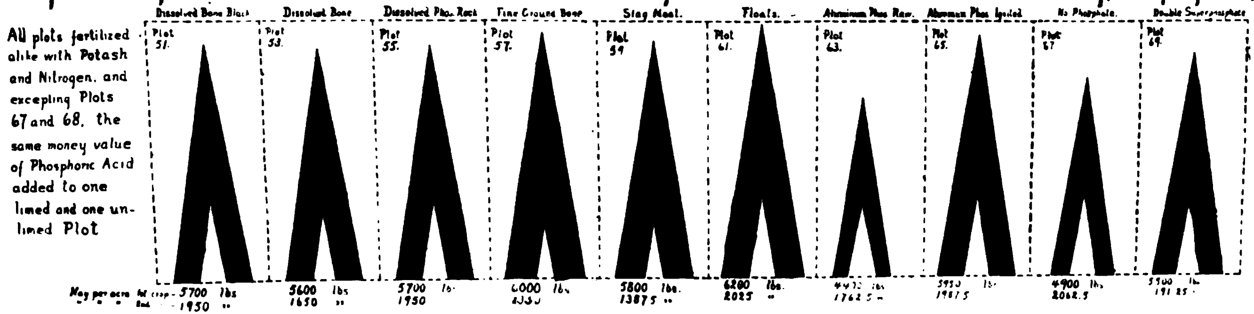
Phosphate Experiment. Plots limed, 1 ton per acre. Field cured hay. crop of 1896.



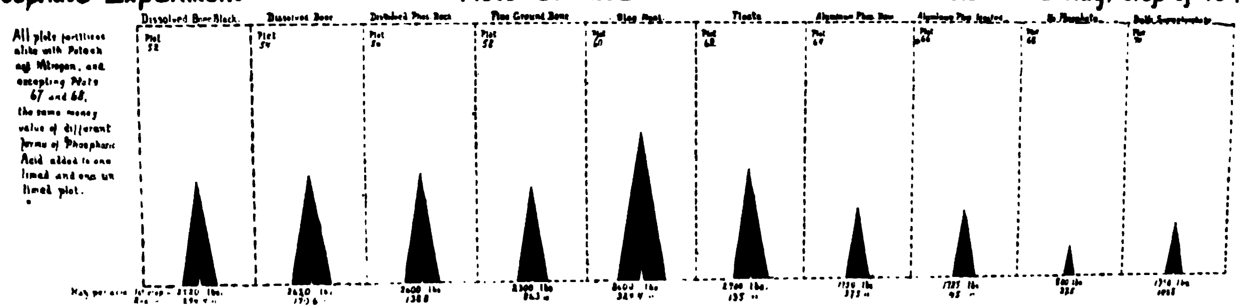
Phosphate Experiment. Plots Unlimed. Field cured hay, crop of 1896.



Phosphate Experiment. Plots limed, one ton per acre. Field cured hay, crop of 1897.



Phosphate Experiment. Plots Unlimed. Field cured hay, crop of 1897.



SUMMARY.

The three insoluble phosphates, fine ground bone, slag meal and floats, thus far maintain the lead in pounds of hay produced, slag meal holding the first place in the unlimed series. The alumina phosphates thus far appear to be quite inferior forms of phosphoric acid when used upon an acid soil without an application of lime; and when in the raw form, even in connection with lime, produced a smaller crop than the plot which received no phosphoric acid. The ignited form, used in connection with lime, produced, in 1897, the second largest yield, but occupies sixth place in the total production for two years. The last one-third ration has yet to be applied as an annual top-dressing to the plots receiving the *soluble* phosphates before all will be on the same basis, but the lead now held by three forms of insoluble phosphate will, doubtless, give them the advantage even then.

The influence of the application of lime in this experiment can, perhaps, be most equitably shown by adding together the yields of the ten plots in each series and comparing the figures. The ten plots equal an acre in area, and the figures thus obtained give an average result from the use of nine kinds of phosphates. Taking the yields of hay for the two years we get the following results:

Total yield of 10 limed plots in 1896	2,888	pounds of hay.
Total yield of 10 unlimed plots in 1896.. ...	1,295	pounds of hay.
Gain per acre by liming crop of 1896........	1,593	pounds of hay.
Total yield of 10 limed plots, 1897, 1st cutting	5,575	pounds of hay.
Total yield of 10 limed plots, 1897, 2d cutting	1,803.75	pounds of hay.
Total crop per acre, limed plots, 1897 ...	7,378.75	pounds of hay.

Total yield of 10 unlimed plots, 1897, 1st cutting	2,199.5 pounds of hay.
Total yield of 10 unlimed plots, 1897, 2d cutting	137.83 pounds of hay.
Total crop per acre unlimed plots, 1897..	2,337.33 pounds of hay.

Gain per acre by liming the crop of 1897—

7,378.75 pounds, less 2,337.33 pounds, is 5,041.42 pounds.

Total hay crop of 1896 and 1897, 10 limed plots.	10,266.75 pounds.
Total hay crop of 1896 and 1897, 10 unlimed plots	3,632.33 pounds.
Gain per acre in hay crop of two years through the application of 1 ton of air-slacked lime per acre in 1894.	6,634.42 pounds.

The above figures show a gain, fairly due to the influence of the lime, of about 3½ tons of hay per acre in the grass crop of two years, and it is reasonable to suppose, from what we know of the effect of lime in other cases, that its influence will be equally manifest for at least two succeeding crops. If, however, we charge the entire cost of the lime, at eight dollars per ton, to these two hay crops, and calculate the value of the increase in the hay crop at fourteen dollars per ton, we have a profit of $38.44 per acre due to the use of lime in connection with fertilizers on an acid soil.

Redtop (*Agrostis vulgaris, L.*) formed the bulk of the hay crop upon the *unlimed* plots, while timothy (*Phleum pratense, L.*) predominated upon the *limed* plots. The fact that air-slacked lime favors the growth of timothy is worthy of note, especially where hay is produced for market, and the price is often seriously affected by the admixture of fine grasses. When soils are acid timothy quickly disappears from the grass fields, and redtop or bent or perhaps sorrel takes its place.

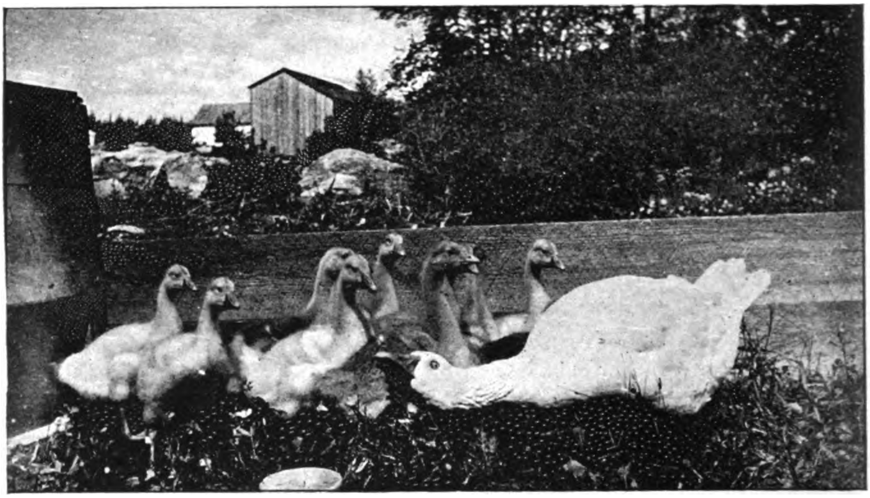


Fig. 1. An Interesting Family.

GOOSE BREEDING.

CHAS. O. FLAGG.

At what time in the world's history the goose became a domestic animal literature fails to inform us: but, that together with the waymarks of sculpture, art and science, which indicate the progressive march of humanity through the centuries past, shows us that, in common with the barn-yard fowl, the goose has been a servant of man from the earliest times. Ancient literature ought, rightly, to tell us more about our subject than it does, for, since sometime in the fourth century, the goose has provided the scribes with quills wherewith to record, for our instruction, the great and small events of history; the noble and the base in the manhood of all times since then; the rise and fall of kings and empires; the constant struggle of truth with error, and to picture for us the customs and manners, the loves and sorrows, and the faults and foibles of our ancestors. Though a feather seems a "trifle, light as air," yet the feathers of the goose have had much to do with the physical and mental comfort of mankind, even far back in the centuries, and, although no marble monument has been raised to do her honor, yet the service she has rendered will live so long as written language shall endure.

If we inquire as to the origin of our breeds of geese, we find that there are one or two writers[1] who contend that the wild prototype of the domestic goose does not now exist, and cite the camel as an analogous case. They give as a reason therefor the fact that the domestic goose is the only bird of its tribe systematically polygamous—all the known wild varieties mating in pairs

[1] The Poultry Book, Wingfield and Johnson, page 264, and Dixon Ornamental and Domestic Poultry, page 145, *et seq.* (2d edition).

for breeding, and this applies even to the wild Canada goose now in domestication. The large majority of authorities, however, is united in the belief that the common domestic goose is descended from the indigenous wild goose of the British Islands known as the graylag goose. The name is sometimes given as "gray-leg" or "grey-legged goose," but lacks point, as the bird is gray in plumage, while the legs are yellowish in color; at the same time the term *lag* had no reasonable explanation until, in 1870, Prof. Skeat suggested that the appellation was given because this goose lagged behind when other varieties of wild geese migrated, which was the case in early times. This goose (*Anser ferus*) is found throughout middle and northern Europe and Asia, migrating to marshes and low grounds or islands in the north during the summer season. The graylag goose breeds in more southern latitudes than the Canada goose, and seldom, if ever, visits the far north as does the latter. The size is a little larger than that of the Canada goose (*Anser Canadensis*), in a wild state specimens often weighing ten pounds. While many of the goose family, which includes some forty species, live largely upon insect, animal and vegetable life, found in or close by the bodies of water which they frequent, the domestic goose is eminently a grazing animal. In early life its most rapid growth is made upon a pasture of short nutritious grasses, supplemented with a little grain. Good pasturage, with water for drinking only, will produce well grown geese as easily as sheep or cattle.

Darwin says:[1] "hardly any other anciently domesticated bird or quadruped has varied so little as the goose," and Hewitt says:[2] "My opinion is that the graylag is probably the original stock from which all, or at least most of our common varieties sprang, my idea being based on the fact that frequently we see the most unquestionable tendency to "breed back," a bird having all (or nearly all) of the traits of character of the graylag, even when the parent birds did not exhibit the slightest resemblance."

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[1] Animals and Plants under Domestication, Vol. 1, page 302.

[2] Poultry Book by Wingfield and Johnson, page 268.

The graylag goose is thus described:[1] "The bill is pale flesh-colored yellow, somewhat lighter than the legs; the nail, at its extremity, being white. The neck and back are ash grey; wings, a light brown, the edges of the feathers running into a lighter tint, while the lesser wing-coverts are of bluish gray, in contrast to the darker hue of the wing generally, a peculiarity that often serves to distinguish this species in both adult and immature specimens; the breast and front of the neck light ash grey, the former being lightly barred with transverse markings, tail coverts and under part of the body, white, tail feathers a dull brown with a white margin. The "curl" of the neck feathers, so remarkable a feature in the domestic goose, is strongly marked in this species."

The characteristic last named, the curled or twilled appearance of the neck feathers, is a very prominent marking in both the Embden and Toulouse geese of to-day. It is, however, almost wholly absent in the case of the White China and Brown China geese, in which the tendency toward an erect carriage is marked, and, taken together with the prominent "knob" or protuberance at the base of the upper mandible, the harsher, shriller voice and greater prolificacy, points to a different origin or to much greater changes in characteristics, through domestication and selection, than in the case of the Embden and Toulouse breeds. Naturalists give the Chinese goose the name of *Anser cygnoides* and Wright[2] quotes Blyth as authority that the common domestic goose of India is a hybrid between this goose and the graylag, and says: "It is very remarkable that these hybrids appear perfectly prolific and perpetuate the cross with a little care; not, as is usual with crosses, reverting to either of the parent races." Is not this hybrid the original foundation of the African goose as bred at the present time? The names African and India are used interchangeably by many goose breeders, and the characteristics of the breed show modified Brown China traits. The general color of the plumage is much the same, and the dark brown stripe on the

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[1] *Ibid*, page 262.

[2] The Illustrated Book of Poultry, pages 557-566.

back of the head and neck, which is so strongly characteristic of the China, is retained, and also the knob at the base of the upper mandible, although considerably reduced in size in proportion to the relative size of the birds. The dewlap, or pendant skin under the throat, which Wright[1] and Brown[2] say is a distinguishing characteristic of the Chinese goose, is now required[3] fully developed in African geese, and *is not now* countenanced in the pure Chinese breeds.[4]

Darwin says:[5] "Although the domestic goose certainly differs somewhat from any known wild species, yet the amount of variation which it has undergone, as compared with that of most domestic animals, is singularly small. This fact can be partially accounted for by selection not having come largely into play. Birds of all kinds, which present many distinct races, are valued as pets or ornaments, no one makes a pet of the goose, the name, indeed, in more languages than one, is a term of reproach. The goose is valued for its size and flavor, for the whiteness of its feathers, which adds to their value, and for its prolificness and tameness. In all these points the goose differs from the wild parent form, and these are the points which have been selected. Even in ancient times the Roman gourmands valued the liver of the *white* goose; and Pierre Belon, in 1555, speaks of two varieties, one of which was larger, more fecund, and of a better color than the other; and he expressly states that good managers attended to the color of their goslings, so that they might know which to preserve and select for breeding."

White is evidently a color developed by domestication and selection. The estimation in which white birds were held by the Romans no doubt led to their preservation as breeding stock, but the custom of plucking live geese for the feathers, followed probably for hundreds of years, has, no doubt, had its influence, as

[1] Illustrated Book of Poultry, page 566.

[2] Pleasurable Poultry Keeping, page 228.

[3] American Standard of Perfection, page 238.

[4] *Ibid*, pages 239 and 240.

[5] Animals and Plants under Domestication, Vol. I, page 304.

bird and poultry keepers know that a white feather is often produced in place of a colored one pulled out. It has been said of the common domestic geese of England,[1] that "the ganders are usually white, or with a preponderance of that color, while the geese have various shades of ash grey and a dull leaden brown mixed with it; a preference is often expressed for those that have no white whatever, excepting only on the lower part of the body." Wright refers to this preference of color in mating, when for certain reasons he advises the crossing of a Toulouse gander with Embden geese, he says:[2] "It also affords some amusement to the owner, as it altogether upsets at once the theory of many old farm mistresses, that the gander is the white bird and the geese particolored." The breeding of white geese has also had some encouragement because of the greater value of *white feathers* as compared with colored or feathers of mixed color, and because the dressed bird has a brighter and cleaner appearance, more pleasing to the eye than that of a dark feathered bird, and which therefore helps its sale in the market. An English authority says:[3] "All white aquatic poultry are considered to dress *i. e.* to 'pluck' of a clearer and better appearance than the particolored or dark feathered birds, more especially whilst young. This arises from the patches, where the dark feathers grew, showing even after being carefully plucked, more particularly if the plumage at the time they are killed happens to be immature. Although when roasted no difference is perceptible, yet a clear skinned bird always commands the most ready sale." This partiality of the public for that which presents a *fine appearance* is manifest in the development of the *white* breeds of fowls so popular with those engaged in the raising of broilers; the Pekin duck in this country, and the Aylesbury duck in England.

Aside from color, domestication and selection have changed the goose in respect to size and fecundity. From the wild type,

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[1] The Poultry Book by Wingfield and Johnson, page 266.

[2] The Illustrated Book of Poultry, page 563.

[3] The Poultry Book, Tegetmeier, page 315.

weighing at maturity about ten pounds each; have been developed, in the course of time, birds weighing on exhibition sixty pounds per pair, and thirty-eight pounds for a single male bird. These are extreme weights, it is true, but it is no uncommon thing for green geese at twelve weeks old to weigh from twelve to fifteen pounds each, and at four or five months old to reach eighteen to twenty or more pounds, dressed weight.

As before stated, the domestic goose, of all the goose family, is the only one where the gander quite regularly mates with more than one goose. He, however, seldom mates with more than four geese, and often with less, usually having one favorite whom he guards more jealously than the others, and whose nest he is ever ready to defend against all comers. The wild graylag goose lays generally from five to eight eggs, and has been known to lay twelve to fourteen,[1] while some varieties of the domestic goose, if not allowed to sit, will sometimes lay sixty or more eggs in a single season. Selection of breeding stock and feeding have much to do with the egg production. Rankin says[2] in regard to the laying qualities of African geese: "Thirty years ago I rarely had a bird that would lay over thirty eggs; now they often lay sixty, and occasionally more." A California correspondent to a poultry paper, states[3] that he kept one pair of Toulouse geese, and in 1885 the goose laid 65 eggs, of which number 53 were set under hens and every egg hatched. As a rule the Chinese geese lay more eggs than other varieties.

The wild graylag goose interbreeds with the domestic goose, and the progeny is fertile.[4]

The wild Canada goose is quite readily domesticated, and the ganders will usually mate the second or third year with a domestic goose. A dark colored female, usually Toulouse or African, is

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[1] Morris' British Birds, Vol. X, page 89.

[2] Lecture on Profitable Geese raising, R. I. State Board of Agriculture Report, 1896, page 422.

[3] *The Poultry Keeper*, Vol. II, page 166.

[4] The Poultry Book, Tegetmeier, page 312, also the Poultry Book, Wingfield and Johnson, page 260.

selected for such mating, and the progeny is the "mongrel" goose so highly prized for the table, and which always far exceeds the price of other geese in the market. The wild female is seldom mated with the domestic gander, as she lays but few eggs, and the production of "mongrels" from such matings is very limited and hardly profitable. The "mongrel" progeny of either mating is sterile. Audubon says:[1] "The greatest number of eggs I have found in the nest of this species (Canada goose) was nine, which I think is more by three than these birds usually lay in a wild state. In the nests of those which I have had in a domesticated state I have sometimes counted as many as eleven. Several of them, however, usually proved unproductive. They never have more than one brood in a season unless their eggs are removed or broken at an early period."

The successful breeding and rearing of wild (Canada) geese and "mongrels," or hybrids between the wild and African or Toulouse goose, is the perfection of art in goose raising, and only those who are thoroughly familiar with the habits and peculiarities of the wild as well as the domestic goose, and so situated as to provide each pair of them with abundant space, including a natural supply of water in some secluded locality in which they may reign supreme, can hope for good success.

The few men who are successful breeders of mongrel geese have as a rule grown up in the business from boyhood, and have a life-long apprenticeship combined with infinite patience and tact.

It has been said that no class of poultry can be produced with so little expense for shelter, food, labor, and care, as geese. This statement is true when their habits and requirements are thoroughly understood and met, and it is equally true that no class of poultry can be more disastrously unsatisfactory under opposite conditions. The habits and peculiarities of the five common varieties of domestic geese bred in this country are generally uniform and resemble those of the wild goose; modified as would be expected

[1] Birds of America, Vol. VI, page 184.

by centuries of domestication. Whether in the course of time the Canadian gander will become polygamous, and the goose develop an egg producing capacity two to five times as great as at present, is problematical, but one would say quite possible in view of the changes which selection and domestication have produced in the case of our breeds of domestic geese. In order that the novice may have some idea of the conditions to be met in successful goose rearing, before enumerating the domestic varieties we will endeavor to point out some of the peculiar habits of geese.

PECULIARITIES.

We very often hear the word goose used to designate a person as silly, or to characterize some foolish action. This use of the word, as indicating a popular opinion regarding the stupidity of the bird, is resented by those familiar with their habits as owners and breeders of geese, and even some authors declare the opinion erroneous.

A writer in the "Cornhill Magazine"[1] says, in regard to the popular use of the word, "It being only ignorance of the darkest hue that ventures to portray the goose as deficient in sagacity and intelligence." Probably this erroneous popular opinion may be attributed to the one quality of timidity, and the liability of the goose to act very foolishly when frightened, more than to any other trait.

Those who adhere to the popular conception regarding geese may not appreciate this trait of timidity, in view of the traditions one often hears regarding certain courageous and pugnacious ganders which at times have inflicted serious injuries upon strong men. Geese have thereby obtained credit for a degree of courage and a spirit which is not usually theirs, or manifest only during the breeding season and while the geese are sitting. Perhaps no other domestic fowl requires to be more quietly and carefully cared for than the goose. Undue excitement, or disturbance by

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[1] Volume VIII, page 208.

visitors, strange dogs or animals, often has a very injurious effect upon them, especially in the laying season. One breeder says that he has known geese to be so badly frightened from the throwing of a few cabbages into the yard as to effect the egg production. A very nervous or fractious person does not usually have very good success in the handling of geese. They require the kindest of treatment, and the breeder should be thoroughly familiar with the individuals of his flock, and on the most intimate terms with them in order to attain the best success. With this trait of timidity is its counterpart—extreme watchfulness. Geese are ever on the alert, and one breeder asserts that geese are better than any watch-dog for giving notice of the approach of strangers during either daytime or night. One goose breeder who claimed membership in one or two societies, and occasionally came home quite late in the evening, asserted that he could always get into the house without disturbing his watch-dog, but he never in his life succeeded without arousing the gander, which gave due notice of his approach. It was this trait of watchfulness which gave to geese the credit of saving Rome from surprise and capture, through a silent and stealthy night attack of the enemy, as early as 388 B. C. Then geese were kept as sacred to the queen of the Roman gods, Juno, which sacredness implied great antiquity.[1]

The graylag goose, in a wild state, feeds in flocks of greater or less size and always with sentinels on guard ready to sound an alarm upon the slightest approach of danger. Bishop Stanley[2] says "no animal biped or quadruped is so difficult to deceive or approach." The Canada goose is equally watchful and wary of anything which threatens the safety of the flock. Audubon[3] says "in keenness of sight and acuteness of hearing they are perhaps surpassed by no other bird." Their ability to distinguish between sounds made by wild animals, as the breaking of a twig by a deer or the splash of water by a turtle, and similar sounds

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[1] Animals and Plants under Domestication, Darwin, Vol. I, page 302.

[2] British Birds, Morris, Vol. V, page 85.

[3] Birds of America, Audubon, Vol. VI, page 188.

produced by the approach of the hunter, is phenomenal. When one wishes to define an undertaking as exceedingly doubtful as to profitable results, he can use a no more expressive term than to characterize it as a "wild goose chase." That proverbial saying has its foundation in the watchfulness, acuteness, and capacity to look out for its own safety and that of its family possessed by the goose.

As intimated, ganders, during the breeding season, and even the geese when sitting, or in defence of their young, manifest considerable courage and often punish intruders severely. When interfered with they seize the intruder with the bill, strike with the wings, and sometimes scratch with the claws. They have sufficient power in the jaws to bite quite hard, and a large, full grown gander has been known to strike hard enough with the wings to break a person's arm. It is very rarely, however, that a gander kindly cared for and treated well, becomes habitually ugly so as to attack people without provocation. The ganders fight among themselves whenever one colony intrudes upon the territory of another, and their battles are severely fought, usually with the wings, one gander seizing the other by the first joint of the wing with the bill, and beating him with his wings while thus held. Unless separated at such times, they are liable to receive injury; however, where large parties run together, accustomed to each other's society, they usually understand their position and relations, so that very little, if any, difficulty is experienced from fighting.

As has been before stated, geese are grazing animals to a greater extent than any other class of poultry. In fact they live and thrive on good pasturage and water, although of course they do not make the rapid growth that may be secured when some grain is fed; on the other hand, however, it is not possible, probably, to raise goslings on an exclusive grain diet without a liberal supply of clover, cabbage, roots, apples or some succulent vegetable food. Young goslings make the most rapid growth upon short nutritious grass and cracked corn or wheat. In a wild state,

geese devour large quantities of roots of grasses and aquatic plants, which they dig from the banks and borders of streams and wash free from earth in the shallow water. Domestic geese confine themselves less to water and aquatic plants and generally feed upon pastures, preferring moist, rich localities where the grass is kept short and sweet by constant feeding and rapid growth. Tall woody grasses, which have become tough, are not relished by them. This natural habit of geese makes considerable space necessary for their successful keeping, or requires that they be provided with succulent green crops, such as rape, cabbage, sorghum, corn, oats, etc.

Broods of goslings of different ages, hatched and reared on the same farm, must, of necessity, be penned while young, each brood by itself, and as they go out to feed on the pasture or field each flock invariably keeps by itself. Any intruder or visitor from another flock is very unwelcome, and is scolded, bitten, and driven out of the flock by common consent. This clannish rule is peculiar to geese and very strictly enforced. Saunders says:[1] "If we traverse a pasture or common on which geese are kept, we find the flocks of the respective owners keeping together; and if by chance they mingle on the pond or sheet of water, they separate towards evening and retire, each flock to its own domicile. On extensive commons, where many thousands of geese are kept, the rule is scarcely ever broken; the flocks of young geese, brought up together as their parents were before them, form a united band, and thus distinct groups herd together, bound by the ties of habit."

An old adage, more expressive than elegant, says: "The goose eats everything before it and poisons everything behind it," but doubtless it had its origin in the mind of some enemy, as when geese have sufficient pasture it is not true. Upon this point Dixon says:[2] "They are accused by some of rendering the spots where they feed offensive to other stock, but the secret of this is very

[1] Domestic Poultry, Saunders, page 90.

[2] Ornamental and Domestic Poultry, Dixon and Kerr, page 416.

simple. A horse bites closer than an ox, a sheep goes nearer to the ground than a horse; but after the sharpest shaving by sheep the goose will polish up the turf and grow fat upon the remnants of others. Consequently where geese are kept in great numbers on a small area, little will be left to maintain any other grass-eating creatures. But if the commons are not short, it will not be found that other grazing animals object to feed either together with, or immediately after, a flock of geese."

Unlike gallinaceous fowls, the goose has practically no crop, although an enlargement of the end of the gullet next the gizzard in some measure serves to hold food, consequently it feeds at very frequent intervals, and during warm weather often eats more at night than during the day-time, a point which should be remembered in feeding and caring for them.

Geese have great constancy, another trait which is not appreciated except by those who have had considerable experience in raising them. This term applies to their attachment for each other, and also to their home and surroundings.

The wild Canada gander usually mates with but one goose, and, once mated, is constant in his attachment to the goose of his choice so long as she is allowed to remain with him. The domestic goose seldom mates with more than three females, occasionally with less, and is almost equally constant in his adherence to the mates he has selected. If, for any reason, he is separated from his mates and placed with others, he will seldom accept them so long as his old mates are anywhere within hearing distance, and, even when they are entirely removed from the premises, it frequently takes some time before he will become reconciled to his new mates. The wild gander almost never mates the first year, and frequently not until the third season, and is much more particular about accepting a new mate if deprived of one to which he has become already attached. Young geese are not fully mature at twelve months old, and the experienced breeder never expects the best results in egg production and fertility until the second or third season.

These peculiarities of geese are not appreciated by the novice, and because eggs fail to hatch, and poor results are attained the first season, the business of goose raising is given up when really a proper trial under suitable conditions has not been made.

Geese become attached to the locality in which they are kept and are much disturbed when removed to a new location; hence, when such removal is necessary, or when a beginning is to be made in the keeping of geese, breeding birds should be placed in their new quarters some weeks before the laying season begins, or a good number of fertile eggs will probably not be obtained.

Geese have a long tenure of life, far exceeding any other domestic fowl in this respect. In former times it was not uncommon for the farmer's daughter, on her wedding day, to receive, among other gifts, a goose from the old homestead, to become her property and accompany her to her new home. In some instances such geese were kept for many years, perhaps far beyond the life of the young lady to whom it was presented.

Such a goose was exhibited at the New Jersey State fair, in 1859,[1] and her history, on a placard posted on the coop, read as follows: "Madam Goose is now owned by Robert Schomp, of Reading, Hunterdon County, N. J. She has been in his possession twenty-five years, and was given to him by his grandfather, Major H. G. Schomp. Robert's father is now in his eighty-fifth year, and this goose was a gift to his mother as a part of her marriage outfit. The mate of Madam Goose was killed in the revolutionary war, being rode over by a troop of cavalry. * * In the spring of 1857 she laid six eggs, three of which were hatched, and the goslings raised. In 1858 she made seven nests and laid but two eggs, evidence perhaps of failing faculties. Her eyes are becoming dim, one having almost entirely failed. The year of her birth cannot be known, but she remains a representative of the oldentime."

William Rankin,[2] a veteran goose breeder, cites the instance of

[1] The Market Assistant, DeVoe, page 143.

[2] Report of R. I. State Board of Agriculture, 1896, page 423.

a goose owned in Boxford, Mass., where it was the property of one family for 101 years, and was then killed by the kick of a horse. She had laid 15 eggs and was sitting on them when a stray horse approached too near the nest; she rushed off, in defence of her eggs, seized the horse by the tail, and was killed by a kick from the animal.

The same gentleman, about 25 years ago, purchased in this State a wild gander which had been owned by one family some 50 years. A member of the family had wounded the gander by firing into a flock of wild geese, breaking his wing. The gander recovered from his injury and was kept for that number of years, without, however, mating with other geese. He is now kept and used as a decoy bird during the gunning season, and highly valued by his owner, although at least 75 years old.

Willoughby[1] records the instance of a goose that had reached the age of 80 years, and was at last killed for its mischievousness.

Some goose raisers say that geese seldom get too old to be good breeders, while occasionally one prefers geese from two to five years old. Barring accidents, good geese may be profitably kept until 25 or more years old; ganders of the domestic varieties, however, are less useful after 7 or 8 years, and should be replaced with young birds. While the young gander often mates with three or four females, he usually has one particular favorite among the number, whose nest he guards more jealously than those of his other mates, and after some years he is liable to grow so inattentive to all but the favorite that many of the eggs produced prove to be infertile, and it is more economical to replace him with a younger bird. The Canada gander is, however, a pretty sure and valuable breeder for many years.

Ganders occasionally take very peculiar freaks, such as conceiving a violent attachment for some inanimate object, as a door, stone, a cart wheel, a plow, or something of a similar nature, when they will spend the greater part of their time sitting beside

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[1] British Birds, Morris, Vol. V, page 84.

it or in its company. Morris[1] relates a number of instances where ganders have become the inseparable companions of their masters, following them about the fields, on hunting expeditions, and into the streets of a town, like the most devoted dog. He also narrates how faithfully a gander discharged the self imposed duty of guardian and guide to an old blind woman. Whenever she went to church he directed her footsteps into safe paths by taking hold of her gown with his bill, and during the service he nipped the grass in the cemetery close by until she required his services as guide to return home.

Geese are peculiar, in that both sexes are feathered exactly alike. Consequently there is considerable difficulty in distinguishing ganders from geese, especially when young. Some experienced breeders determine the sexes by the difference in the voice, but that is a knowledge gained only by considerable acquaintance with geese. The form, size, length of neck, and size of the head, is some indication as they approach maturity, the gander being heavier, with a longer neck and larger head than the goose. A critical examination of each bird is a pretty sure method, but even this fails at times when made by a novice. On this subject Bailey says,[2] "much difficulty is often experienced in selecting the sexes, and although practiced men are seldom mistaken, yet even they can lay down no rule that is easy to follow. Close examination may always be depended upon, but that is not easy to the uninitiated. There is a curious plan adopted in Cambridgeshire. All the geese are shut in a stable or a pig-stye; a small dog is then put in. It is said, and we believe with truth, the geese will all lift up their heads and go to the back of the place, while the ganders will lower and stretch out their necks, hissing all the time."

Before the days of steam or furnace heated houses and coiled spring mattresses, live geese feathers were a more important item and commanded a higher price than at present, and the fact that

[1] British Birds, Morris, Vol. V, page 85-87.

[2] Fowls. Bailey, pages 125 and 126.

the breeding birds could be plucked from one to three or more times a season was an inducement to the keeping of geese which has very little force now. Comparatively few men pick any geese alive as in former days. The feathers obtained from the goslings fattened and killed for market are quite a source of income to the large dealer, as a good gosling will yield about enough feathers at present prices to pay the cost of picking.

Geese are less liable to disease than any other domestic fowl, which, possibly, may account in some measure for their generally long life. Goslings well hatched are seldom lost, except through accident or exposure to hard storms while still very young.

From the characteristics enumerated it is easily seen that the business of goose raising is of necessity somewhat restricted. It cannot be conducted in such a wholesale concentrated manner as is duck raising at the present time. The relatively large number of males required, the exclusiveness of the gander and his mates, the comparative large amount of range necessary for the breeding stock, and their aversion to close confinement, are some of the reasons why very large numbers cannot profitably be kept together. For the above reasons the business of goose breeding is never likely to be monopolized by a few breeders on a grand scale, but is likely always to remain in the hands of the many farmers who have low lying lands along brooks, rivers, and ponds, which, while comparatively worthless for other purposes, furnish ideal conditions for successful goose breeding.

VARIETIES.

Many geese are kept which are of no particular breed, having descended from the importations made by the early settlers. They have probably been more or less crossed with the improved breeds during the last fifty years, but present no fixed colors aside from white, gray, or particolored, nor special type of body. Of the breeds usually met with, Toulouse is probably most common, and African and Embden share with it the honor of being popular breeds. Brown and White China, as pure breeds, are not so

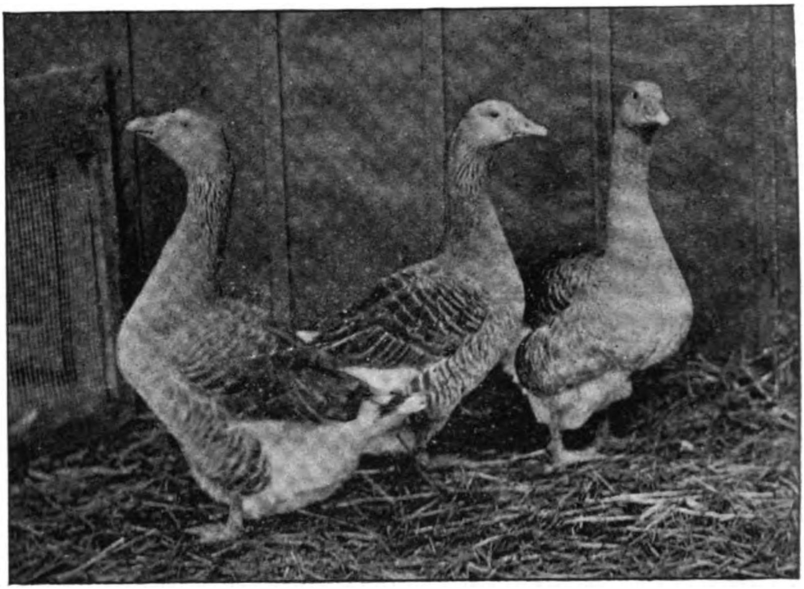

FIG. 2. Toulouse Geese.

popular unless for ornamental purposes, the Canada goose is bred pure to furnish a supply of ganders for the breeding of "mongrels," and occasionally the Egyptian goose is bred solely for ornamental purposes.

TOULOUSE.

This breed takes its name from one of the cities in southern France, although it was from Marseilles, a city in the south-east of France, that this goose was first imported into England. It probably reached this country at a later date than the Embden or Bremen and African or Hong Kong breeds, as a prominent poultry judge[1] in a personal letter states that he saw both those breeds at exhibitions at an earlier date than the Toulouse.

This goose is massive in appearance and has probably reached a greater weight than any other variety—60 pounds per pair having been recorded[2] at an American exhibition. It matures more slowly than other varieties, and in order to look well when dressed requires to be well fattened, so as to fill out the loose skin forming the abdominal pouch which characterizes this breed even when a few weeks old. When pure bred they are better for the Thanksgiving and Christmas trade than for dressing as "green geese" at twelve weeks old, but crossed with the Embden or African breeds they grow more rapidly and mature earlier. Toulouse geese usually lay more eggs in a season than Embden or African geese, but not as many as the best China geese. They are nearer non-sitting than any other variety, but some individuals make good mothers. The goslings are greenish yellow in color, generally hardy and vigorous. They are quiet and peaceable, and more easily confined by stone fences than other breeds, and would be more likely to be contented in close quarters. Toulouse geese are gray in color, with a square massive body, carried fairly horizontal, the abdominal pouch, or loose folds of skin between and behind

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[1] Mr. I. K. Felch.

[2] Poultry Culture, Felch, page 404.

the legs, almost or quite touching the ground. The shoulders should be broad, the neck medium in length and moderately stout, the head and bill strong and presenting a fairly uniform curve over the top to the bill, which is reddish with a whitish or flesh colored nail at the extremity. The eye is brown or hazel, the rim usually the color of the bill. The throat has a fold of pendant skin known as a "dewlap," less prominent, however, than the African. The feathers of the neck are decidedly curled or twilled from the head toward the shoulders. The head, neck, back, and thighs are a dark gray shaded with brown, breast, gray, but gradually shading into white at the abdomen, which color extends to the tail. The tail is white, with a band of gray across the center of the top. When viewed squarely in front little, if any, white should be seen, and the breast should be broad and full. The legs are rather short, stout, of a deep reddish orange color, and placed well apart. The gander and goose are exactly alike in feathering and color, and it is often difficult or impossible to distinguish the sexes by appearance only. Standard weights are, for adult gander, 25 pounds; goose, 23 pounds; young gander, 20 pounds; and goose, 18 pounds.

EMBDEN.

In size, for exhibition purposes, this variety must be the equal of the Toulouse, although 54 pounds per pair is the highest American record of weights of which we have knowledge, but Felch[1] says: "fully one-third the exhibitions show Embdens of greater weight than the Toulouse, and we are of the opinion that the Toulouse is susceptible to greater growth for extra care, while the Embden is better grown under neglect."

The Embden considerably resembles the Toulouse in form, having descended without doubt from the same parent stock, but must be pure white in surface color. It has the same decidedly curled or twilled appearance of the neck feathers, but the abdominal pouch is but slightly developed, as compared with the

[1] Poultry Culture, page 404.

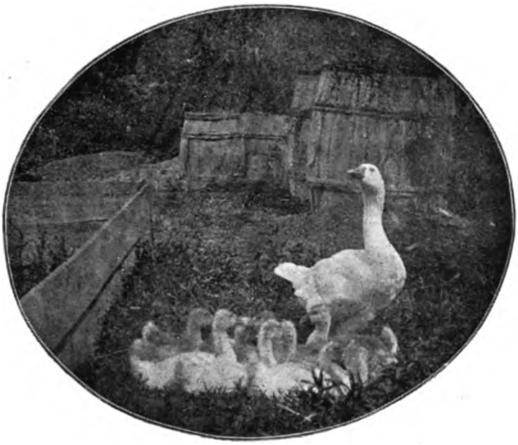

Fig. 3. Embden Goose with Brood.

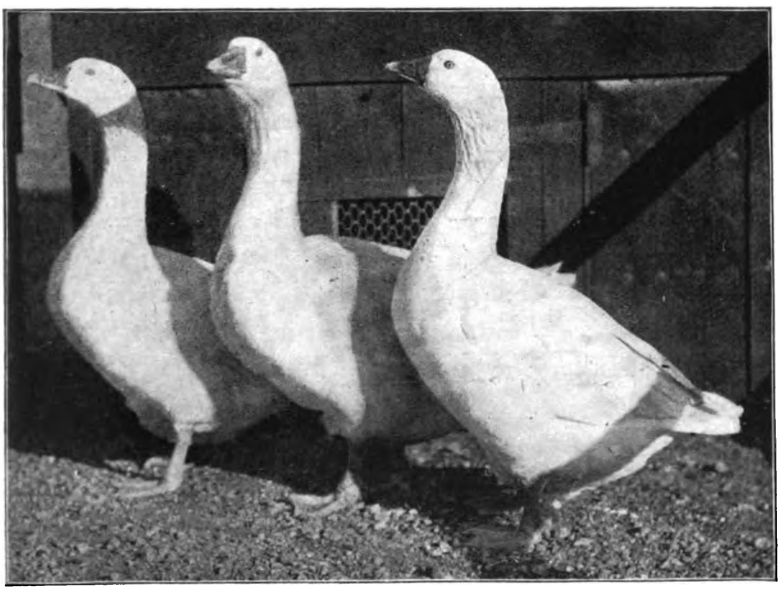

Fig. 4. Embden Geese.

Toulouse, consequently the body of the bird appears a little higher from the ground. The neck and head should be of fair size, avoiding a small or shaky appearance. The American standard color for the bill is a flesh color, but there is often an inclination to orange—the color of the legs, and the English standard requires the bill to be "rich orange" in color. The nail at the end of the bill is nearly white, as also the claws. The eye is bright blue, and the rim the color of the bill. These geese are inclined to lay a little earlier than the Toulouse, and their eggs average a trifle heavier, but they do not lay quite as many eggs and are much more persistent sitters. They make excellent mothers. The goslings when hatched are of a rich yellow color, which changes to white as the quill feathers grow. They are generally hardy and grow rapidly; their perfectly white color makes the dressing of them as "green geese" an easy matter as compared with that of dark colored birds, and when put on the market they are not excelled in appearance.

This breed was first introduced[1] into this country in 1821 by Col. Samuel Jaques, of Boston, who bred them for many years on his estate at Medford, Mass., under the name of *Bremen* geese, as it was from the seaport city of that name, in Germany, he obtained them. The name Embden is derived from a seaport city of Prussia, in the province of Hanover, East Friesland, and it is interesting to note that the letter of instruction to the captain of the ship relative to the care of this importation of 6 geese (2 ganders and 4 geese) is dated "*Emden*, 17th August, 1821."[2] Under date of December 12th, 1850 Samuel Jaques, Jr., writes,[3] "The original stock has never been out of my father's possession, nor has he ever crossed it with any other kind." In 1826 one of the imported females was marked by cutting a hole through the web of the left foot with a gun-wad punch, and in 1850 she was

[1] Burnham's New Poultry Book, page 304, and the People's Practical Poultry Book, Lewis, page 92.

[2] Ornamental and Domestic Poultry, Dixon and Kerrs, page 430.

[3] Ibid, page 431 to 434.

"in as fine health and vigor as any of her progeny. She has never failed to lay from 12 to 16 eggs every year for the last twenty-seven years, and has always been an excellent breeder and nurse." In 1849 one of her brood, at exactly nine months old, weighed 22 pounds. The progeny of this importation was sold in "almost every State in the Union, as also Canada and Nova Scotia."

In 1826, James Sisson,[1] of Warren, R. I., imported a trio from Bremen, and others were imported about the same time by John Giles, of Providence, R. I. In 1852 a pair imported from Bremen, by Burnham,[1] weighed, on shipboard, alive, 55¾ pounds, and was sold with four others, to a gentleman in New Orleans, La., for fifty dollars per pair. When crossed with dark feathered birds, the progeny is most frequently white or pied, and as the latter almost invariably have white breasts and yellow or mottled bills and yellowish legs, they present almost as fine an appearance when dressed as pure white birds. The crosses are desirable for market, but should never be used for breeding, as rapid deterioration in size and quality is almost sure to follow.

AFRICAN.

A veteran goose breeder, William Rankin, says of this breed,[3] "I think the most perfect goose is the pure bred African, as they lay more eggs, mature earlier and make more pounds of flesh in the same time, while they are very vigorous and hardy, and you will almost always raise all you hatch." African geese have a more erect carriage than either the Toulouse or Embdens, but not so erect as the modern Brown and White Chinas. The body should be large and long, well developed through the shoulders and breast; the neck moderately long, of fair size and gracefully curved, head rather large, with moderately long, stout bill, and a knob or protuberance at the base of the upper mandible. There

[1] Domestic Water Fowl, Stoddard, page 54; The American Poulterer's Companion, Bement, page 269, and Burnham's New Poultry Book, page 304.

[2] Burnham's New Poultry Book, page 301, and the People's Practical Poultry Book, Lewis, page 92.

[3] Report of R. I. State Board of Agriculture, 1896, page 418.

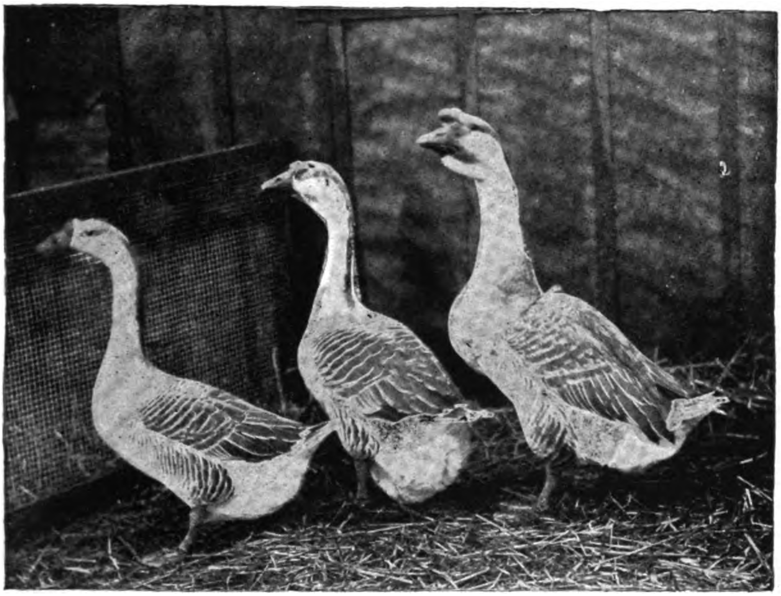

FIG. 5. African Geese.

should be a heavy dewlap or pendant fold of skin under the throat. The bill and knob should be black, and the eyes hazel or brown. The color of the plumage of the back, wings and tail is dark gray, shading to light gray on the breast and under parts of the body. A dark brown stripe extends from the head down the back of the neck. Legs, dark orange in color, with black claws. The notes of this goose resemble those of the Brown and White China much more than those of the Toulouse and Embden breeds.

The utmost confusion prevails in poultry literature regarding the name of this variety. Saunders says[1]: "The principal breeds of geese are the China goose (which is also called the Guinea goose, Spanish goose, African goose, and a host of other names in the English tongue), Toulouse goose and the Bremen or Embden goose." Under the name of China goose he gives a fairly good but very brief description of the African goose. It is true that his description might apply to the *Brown China*, but he makes no mention of a *white* breed under "China."

Bement,[2] under the heading of GUINEA OR AFRICAN GOOSE, says: "This is the largest of the goose tribe which has fallen under our notice: it is the size of the swan, and it often weighs more than twenty-five pounds. We have now in our possession one pair * * * which will weigh, in common, ordinary condition, over twenty pounds each. We once owned a gander that weighed twenty-four pounds." His description of this goose, colors of plumage, knob and dewlap, agrees well with that of the African goose of the present time. He says, "Africa, and perhaps the other southern countries of the old continent, seem to be their native abode," and quotes authorities to prove the identity of the so-called Siberian, Russian or Muscovy goose with the Guinea or African goose. The above, published in 1845, is, so far as we can learn, the first application of the name *African* to this goose. Kerr[3] has a chapter on the CHINA GOOSE, accompanied with an ex-

[1] Saunders' Domestic Poultry. Pub. 1867, p. 92.

[2] American Poulterer's Companion, second edition, pub. 1845, page 271.

[3] Ornamental and Domestic Poultry, second edition, Dixon & Kerr, pub. 1851, pp. 420 to 428.

cellent cut of the African goose, entitled "The Hong Kong, or China Goose," and says, "Of this variety three beautiful specimens were exhibited at the late agricultural show, held in the county of Philadelphia (Penn.)." * * * In introducing this variety to the reader Mr. Dixon says: (edition published in England) "There is a venerable joke about a Spanish Don who knocked at a cottage door to ask a night's lodging. 'Who's there? What do you want?' said the inmates. 'Don Juan José Pedro Antonio Alonzo Carlos Geronimo, &c., &c., &c., wants to sleep here to-night.' 'Get along with you,' was the reply, 'how should we find room here for so many fellows?' The China goose is in the same position as the Spanish Don. It has names enough to fill a menagerie. China goose, knob goose, Hong Kong goose, Asiatic goose, swan goose, Chinese swan (*Cygnus Sinensis*, CUVIER), Guinea goose, Spanish goose, Polish goose, Anas and Anser Cygnöides, Muscovy goose, and probably more beside."[1] (We can add to the list, knobbed goose, African goose and Indian goose.)

"Confusion, therefore, and perplexity, are the certain lot of whosoever attempts to trace this bird in our books of natural history. Its place of birth has excluded it from all monographs or limited ornithologies. In very few systematic works is it mentioned at all, which is remarkable of a bird so striking in its appearance, which there is every reason to believe must have been domesticated for a long period. The uncertainty that has existed as to its correct name, and really native country, may be one cause of this. Like the Jews or the Gypsies it has not been allowed to claim a place among the natives of any one region, and, like many others furnished with a variety of aliases, it ends by being altogether excluded from society." The old writers call it the Guinea goose, for the excellent reason, as Willoughby hints, that in his time (1635-1672) it was the fashion to apply the epithet "Guinea" to everything of foreign and uncertain origin. Kerr adds, in a footnote, "The epithet 'Indian' has also answered the same ac-

[1] The name "African goose" is included with most of the foregoing by Browne in the "American Poultry Yard," pub. 1850, page 222.

commodating purpose." After stating the fact that Cuvier calls this goose and the Canada goose true swans, Dixon continues: "A goose, however, it decidedly is, as is clear from its terrestrial habits, its powerful bill, its thorny tongue and its diet of grass. And, therefore, we have determined to call it the China goose, concluding that Cuvier is right about its home,[1] and other authors about its goosehood."

One of the best authorities upon poultry subjects in England, in a recent work,[2] after naming and describing Toulouse and Embden geese, names the "Chinese," and says: "This variety is not very common in this country, and, though classed with geese, is really more like a swan. It is known as the Oie de Guinee (Guinea goose), of Buffon, and is distinguished especially by its long neck, and a large knob at the base of the bill. From this latter point it has been called the knobbed goose, and also the Hong Kong, from the place of its origin. Although first brought over from China, it is well known in many parts of both the continents of Asia and Africa. It is a very prolific layer, and the quality of the flesh is regarded as superior to that of the common goose. The semi-swan-like appearance gives it a great advantage over the ordinary goose, which is not to be regarded as highly ornamental, but it is smaller in body. In color, the bill and legs are orange, the knob being black. The usual color is a grayish brown on the back and upper parts, passing to white or whitish gray on the abdomen. The fore part of the neck and breast are a yellowish gray, and a very dark brown stripe runs down the back of the head to the body. Some birds are white, with a pale stripe, but in all specimens of the Chinese goose this stripe is present. Another important point must not be omitted, namely, the folded skin attached to the throat, forming a kind of dewlap. As an economic breed this can be recommended, though neither the eggs nor the birds are as large as in the common goose." Mr. Brown does not mention the

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[1] "In journeying overland (in books of travels) we meet with the swan goose more frequently as we approach Tartary and China."—*Dixon.*

[2] Pleasurable Poultry Keeping. Brown, page 227.

African goose, and it evidently has not been bred as a variety distinct from the Chinese, as in the United States. The reader will notice that the dewlap is made an important characteristic of the Chinese geese in England, while in this country it applies to the African, and *not* to the Chinese varieties.

Another English authority,[1] writing upon the breeding of geese, describes only two breeds—Toulouse and Embden—but in an article upon "Breeding geese for the table or market purposes only," says, "Spanish or Canadian ganders may be used for crossing with other varieties, and such crosses are generally very successful." This mention of the "Spanish" goose is the only reference he makes to the English relative of our African goose. As before stated, 1845 is the first record we find[2] of the use of the name African, although under numerous other names the goose had long been bred, probably to about the same type. Felch,[3] in a personal letter, writes: "The African goose, I believe, has been credited to Africa—the region near Zanzibar. It is a goose as heavy as the Embden or Toulouse; has a shorter, thicker neck, and darker gray color than the Brown China; knob and bill are black, with a prominent dewlap—a kind of feathered throat wattle; and a voice harsher and heavier than all others. My own belief is that it is a species indigenous to Africa. We cannot say it is like the Brown Chinas or the domestic goose of India, all of which have longer and more swan-like necks, while the African weighs all of six pounds more than the Chinas. I think that they were imported to this country long before the White and Brown Chinas were received."

A breeder[4] of this variety, with more than thirty years' experience, writes that he first knew of them in 1859, when some were landed at Essex, Mass. What he learned from persons who had

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[1] Henry Digby on Ducks, Geese and Turkeys. (How to make £50 a year keeping ducks, etc.) Pages 111 to 140.

[2] The American Poulterers' Companion, Bement, page 271.

[3] I. K. Felch, Prest. American Poultry Association, 1896.

[4] William Rankin, Brockton, Mass.

them led him to believe that they came from Hindostan, and he called them *India geese,* and all pure bred ones were known by that name. He next found geese landed by a Provincetown (Mass.) vessel, and said to have come from Africa. These birds were scattered about the section west of Boston, and were called Africans, and exhibited by that name. In 1879 they were exhibited under both names, but the name African being adopted about that time in the American Standard of Perfection, the breed has been known by that name ever since. He finds very few pure bred Africans in Rhode Island, many specimens showing admixture of Brown China blood. He has, since 1859, known the African or India goose to be a distinct variety, with a fixed type and breëding, without particular variation.

The American Standard of Perfection requires that the adult African gander shall weigh at least 20 pounds, and goose, 18 pounds; the young gander, 16 pounds, and goose, 14 pounds. This is exactly 4 pounds heavier in each instance than is required by the standard for either Brown or White China geese. As to their laying qualities, doubtless considerable difference exists between different families of the breed. At this Station the average egg production[1] has been less than in the case of either of the other four breeds. For three successive seasons—care and feeding being the same in each case—Mr. William Rankin, however, who has bred African geese for many years, kept careful records of the production of eggs by the individuals of his flock, and always preserved for breeding purposes the best specimens from his most prolific geese whenever any birds were required to replenish his flock, has found them better layers than either Toulouse or Embdens. Under date of February 17th, 1898, he writes in reply to an inquiry: "In 1888 I kept 12 African geese, and the flock averaged 37.42 eggs each. I also kept, the same year, 6 Toulouse geese which averaged 30.68 eggs each, while 10 Embdens, kept the same season, averaged 28.12 eggs per goose. I have since done better with the Embden; I think one goose laid

[1] See tables of egg yields on subsequent pages of this report.

68 eggs in the season of 1895. The product of geese depends largely upon their liberty and food. My African average has always been the largest." In regard to the development of special qualities by breeding, Mr. Rankin says,[1] "Thirty years ago I rarely had a bird that would lay over thirty eggs; now they often lay sixty, and occasionally more. * * * When I was a boy my father used to say, 'If you raise ten goslings from a goose, you are all right.' Now we feel that we ought to raise from twenty-five to thirty." African eggs averaged larger and heavier than those of any other breed kept at the Experiment Station. The goslings are a dark yellowish green color, and usually strong and active. They lay on flesh rapidly and make excellent green geese, although the dark feathers are objectionable in the shape of "pin feathers." They have a quiet, mild disposition when well treated, and feed well when put in the fattening pen, being less liable to rush wildly about, and waste flesh by excitement, than some kinds of geese. This variety is the general favorite for mating with the Canada goose in breeding mongrels.

THE BROWN AND WHITE CHINAS.

These two varieties of geese are smaller than either of the three varieties already described, and are sometimes termed "bantam geese." They are not very largely bred even in a pure state. Many so-called "Brown Chinas" are much too heavy in weight, and not sufficiently erect in form to be classed as pure specimens of that breed. There is evidently considerable intermixture of African blood in many so-called Brown Chinas, as is evidenced by the tendency to develop a dewlap, as well as the larger size and more horizontal carriage of the body.

The thoroughbred Brown China gander should weigh when full grown but about 16 pounds, and the adult goose, 14 pounds; the young gander, 12 pounds, and the young goose, 10 pounds. The body should be round and full, the neck long and handsomely

[1] Report R. I. State Board of Agriculture, 1896, page 422.

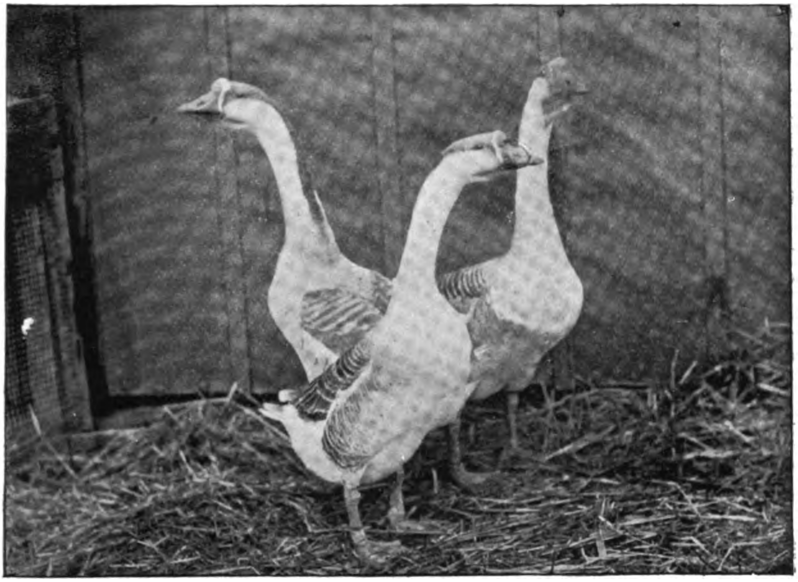

Fig. 6. Brown China Geese.

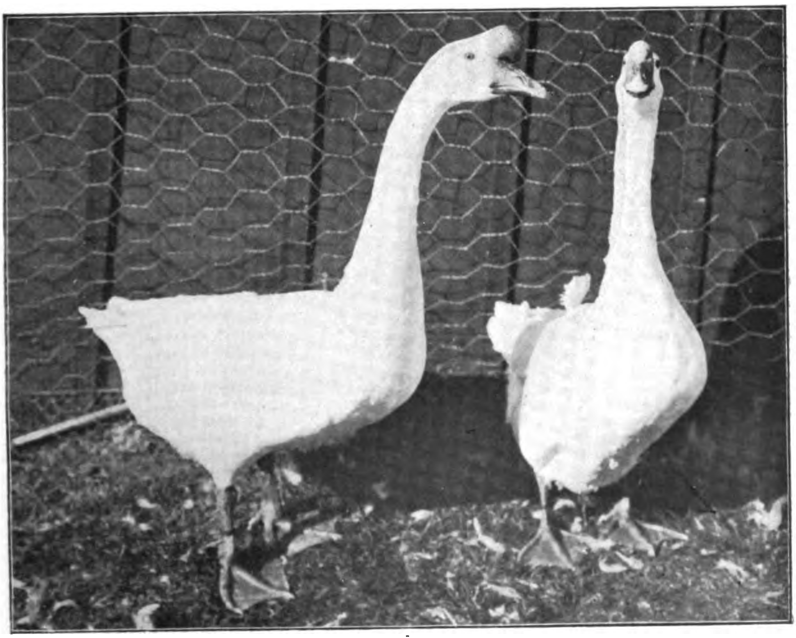

Fig. 7. White China Geese.

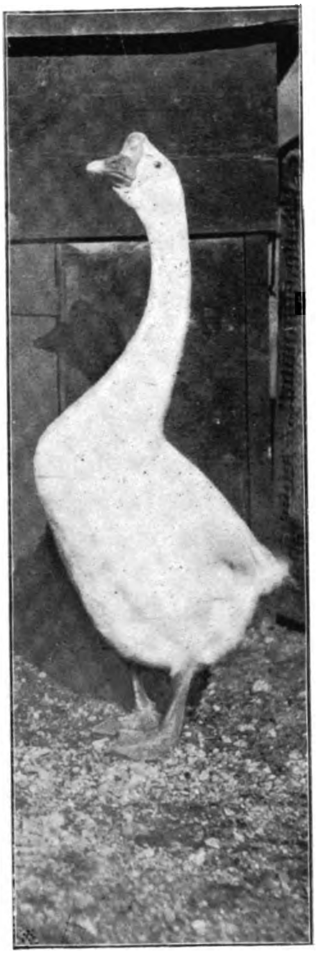

Fig. 8.

White China Gander.

This cut illustrates the erect carriage and proud attitude characteristic of both Brown and White China Geese.

arched. In walking, the body is carried quite erect, and the neck and head thrust upward and forward, giving the bird a tall, important appearance. Head moderately large; bill rather long but comparatively slim, excepting at the base of the upper mandible, which should support a large knob. Color of bill and knob, very dark brown or black. Eyes bright, large, and brown or hazel in color. The distribution of the color of the plumage is much the same as in the African, except that where the African is gray the Brown China should show a decided brown color. The head and stripe down the back of the neck should be dark brown, wings and tail, brown; other plumage grayish brown, shading lighter on the under parts of the body. Legs dark, with a greenish or orange tinge; claws, black.

The White China goose, in size, weight, shape, and style, is the counterpart of the Brown China, but the color should be pure white; the knob should be large and orange colored; the bill orange, with a white nail; the eye a rich blue, with an orange rim; and the legs orange, with white claws. Both breeds have a rather shrill, harsh voice, more noisy and disagreeable than that of Toulouse or Embden geese.

These two varieties of geese are more swan-like in appearance than the African, although all three are doubtless usually included in descriptions of the Chinese goose by some English authors. Dixon, writing of the White China goose, which he describes separately from the "China goose," says:[1] "My attention was first directed to these singular birds by Mr. Alfred Whitaker, of Beckington, Somerset. 'I wish you could have seen the white variety or species, as it is so far superior in every respect to the brown. * * * The White China goose is of a spotless, pure white'—a very few gray feathers have since appeared—'more swan-like than the brown variety, with a bright orange colored bill and a large orange colored knob at its base. It is a particularly beautiful bird, either in or out of the water, its neck

[1] Ornamental and Domestic Poultry, Dixon and Kerr, 1851, pages 446 and 447. See also The American Poultry Yard, Brown, 1850, page 282.

being long, slender, and gracefully arched when swimming. It breeds three or four times in the season; but I was not successful with them, owing, as I fancied, to my having no water for them, except a rapid running stream. * * * My geese were from imported parents and were hatched on board ship from China.'" After the foregoing from Whitaker, Dixon continues: "On visiting town[1] in May, 1848, my efforts to get a sight of any White China geese were unavailing. There were none left in St. James' park; there were not any in the Surrey gardens, choice as that collection is; nor were any visible at the principal places where poultry is offered for sale. The Zoölogical society had parted from their specimens, in consequence of being overstocked with other things. Their head keeper seemed only to consider them in the light of a *variety* of the Cygnöides,[2] but he spoke most decidedly of his experience of the permanence, not only of this variety, but also of that of the dark legged and the red legged sorts of the brown kinds, thus indicating three races, which, I repeat, would be considered as species, were they now discovered for the first time."

Here is pretty conclusive evidence that the "Chinese goose," as described by many of the European writers upon poultry, included within its ranks, fifty years ago, the types of three breeds, in all probability approximating the breeds we, in America, now call African, Brown China and White China. This tends to reconcile the discrepancies in the descriptions of the "Chinese goose" given by various authors, as some doubtless described one type and some another, under the same name. The author quoted above, however, reports very indifferent success in several instances, in endeavoring to breed the White China as a pure breed, although they seemed to be prolific enough when crossed with the common goose. It is quite possible that the difficulty was wholly due to unwise in-and-in breeding.

The Brown and White Chinas are early and prolific layers of fair sized eggs. If well fed, they not infrequently lay in the

[1] London, England.

[2] So called Chinese goose or swan.

autumn months, but generally those which do so lay later and fewer eggs the following spring. At the Experiment Station in 1896 and 1897, the White Chinas laid in every month from January to June, inclusive, while the Brown Chinas did not begin laying until February, but continued laying freely into June. The African and Embden breeds laid about half as many eggs, in proportion to females, kept in February, as the Chinas, and nearly finished laying by June 1st. In 1897, one African egg was laid in January. The Toulouse breed laid about all their eggs in three months, March to May, inclusive, as in the two years only one egg was laid in February, and two in June, by the eight females kept.

There was but the fraction of an egg difference between the average number laid by the Brown and the White Chinas, and the average was higher than that of any of the other three breeds. The eggs of the two China breeds were of about the same average size and weight—5.4 ounces for the White China, and a tenth of an ounce more for the Brown China. This weight is some 1.2 ounces less than the average weight of the eggs of the Africans, and about 0.8 of an ounce less than the weight of those from Toulouse and Embden geese.

China geese are not favorites with those who raise goslings for sale to poultry men who fatten them and put them on the market as green geese. They are too small to be profitable for such a market. When a small boned, moderate sized goose is required for the fall or Christmas trade, these breeds would prove valuable, as they lay well, and, with proper care in selecting breeding stock, large flocks should be raised. The Brown Chinas, especially, seem very vigorous, hardy, and active, but pick hard, and require care in dressing to look well. The White China has, with us, been the poorer breeder, but is usually not so difficult to pick, and handsomer in appearance when dressed.

CANADA.

The wild or Canada goose is bred pure in a domestic state perhaps more extensively than the Brown and White Chinas. In fact, these

three breeds are in demand as ornamental water-fowl for parks and private grounds. The Canada gander is also used for mating with the African or Toulouse goose—the former is preferred—for the breeding of the "mongrel," or "wild mongrel," as it is sometimes called, and which has the reputation of being second only to canvas-back duck in quality and flavor when properly prepared for the table. For this purpose Canada ganders of good size and tested breeding qualities are highly prized, and vary in price from ten to fifty or more dollars each. The importance of *size* in the production of mongrels has doubtless had its effect in the selection of the largest Canada birds for breeding pure; a course which has resulted in more than doubling the size, as is seen by comparing the weights required for this breed in the show room, and the weights of adult wild specimens, as given by Audubon. To win a prize at exhibitions the Canada gander should weigh 16 pounds, the goose 14 pounds; the young gander 12 pounds, and the young goose 10 pounds. Audubon[1] gives the weight of the male Canada goose as 7 pounds, and that of the female as $5\frac{3}{4}$ pounds. We quote the description of this goose from the same author. "Head small, oblong; bill shorter than the heads; neck long and slender; body full, slightly depressed; feet short, stout, placed behind the center of the body; legs bare a little above the joint; wings of moderate length, with an obtuse protuberance at the flexure; plumage close, rather short, compact above, blended on the neck and lower parts of the body. The feathers of the head and neck very narrow, of the back very broad and abrupt, of the breast and body broadly rounded; wings when closed extend to about an inch from the end of the tail; tail very short and rounded; bill, feet and claws black; iris (eye) chestnut brown; head and two upper thirds of the neck glossy black; forehead, cheeks and chin tinged with brown; lower eyelid white; a broad band of the same across the throat to behind the eyes; rump and tail feathers also black. The general color of the rest of the

[1] Birds of America, Audubon, Vol. VI, pages 194 and 195.

upper parts is grayish brown, the wing-coverts shaded into ash gray; all the feathers terminally edged with very pale brown, the lower part of the neck passing into grayish white, which is the general color of the lower parts with the exception of the abdomen, which is pure white, the sides, which are pale, brownish gray, the feathers tipped with white, and the lower wing-coverts which are also pale, brownish gray. The margins of the rump and the upper tail coverts pure white. Female similar in coloring, although the tints are duller, the white of the throat is tinged with brown; the lower parts are always more gray, and the black of the head, neck, rump and tail is shaded with brown." The mating of Canada and African geese produces a mongrel strongly resembling the Canada goose in color of plumage and distinguishing marks. In dressing for market the feathers of the head, two-thirds or more of the neck, the wings and tail are left on the bird, and serve to identify and guarantee the genuineness of its breeding. When Canada geese are crossed upon white domestic geese the color of the progeny is very uncertain, and, although genuine wild mongrels, their doubtful color causes distrust on the part of the purchaser, and injures their market value. The Canada goose lays usually from 6 to 9 eggs, but occasionally lays more in a domestic state. One breeder of experience[1] has known a wild goose to lay 19 eggs in a single season, but such productiveness is very rare. He also states that, with extra care and feeding, the wild goose may be persuaded to lay two litters of eggs in a season, but ordinarily she lays only one. The Canada female likes a secluded place for nest making, where she will be free from disturbance, and, like the wild or wild-cross hen turkey, is liable to steal away to some unfrequented spot which she can utilize for that purpose. In the spring of 1897, the writer, walking across a pasture, was much startled by the sudden screaming, hissing outcry of a wild goose, as she departed, half running and half flying, from her stolen nest. She was sitting upon 6 eggs, all of which she

[1] Mr. Horace Miner.

hatched. She was about a fourth of a mile from the house of her owner. The goslings are hardy little fellows, imbued with some of the independence and self-reliance born of an ancestral life in the woods and fields not many generations back. They are of a muddy green color, with dark bill and legs. After hatching, their care and feeding does not vary materially from that given to goslings of the domestic breeds.

IMPROVEMENT OF BREEDS.

Very few of the great number of breeds of domestic live stock of all kinds, including poultry, are the pure, direct, and only breed descended from a single wild species. Crosses, natural or artifical, have been made from time to time, which, by long years of patient, persistent, and systematic selection and breeding, have resulted in fixed types, possessing certain desirable qualities, and capable of reproducing the same, which are then called *breeds*. These breeds are a great improvement over the original stock from which they have been derived, in that the size, the ability to produce flesh, milk, wool or eggs economically in proportion to food consumed; to develop speed, to exert strength, or to please the eye by beauty of proportion or color, far exceeds that possessed by the original type. In the development of breeds, all has not been gain. Too often constitutional vigor has been impaired, and ability to withstand disease lessened, while in some cases the predisposition to lay on flesh has gone so far as to seriously interfere with normal reproduction. In-and-in breeding, which has almost universally been employed in the production of new breeds, has been cited as the cause of the faults just enumerated. While it is certainly true that injudicious and unscientific in-and-in breeding will ruin the constitutional strength of the progeny, it is equally true that without some inbreeding it would be impossible to develop and maintain the good qualities of different breeds. Few, if any, breeds of stock have reached a point where further improvement is not possible, but the greater the perfection the more difficult the improvement. Our breeds of poultry have been

developed to a point of great perfection in form and plumage, but how much yet remains to be done in the way of egg production? As the profit from goose breeding is almost wholly in the number and market value of the young birds produced, the quality of large egg-production is an all important one. As has been mentioned on a previous page, this quality is affected by the care and feeding, and may be increased by attention to the selection of both ganders and geese from noted egg laying strains. This is only possible by keeping an accurate record of the eggs laid by individuals in the flock, and how few goose breeders do this? The tendency to rapid growth and early maturity, combined with good size and a small proportion of bone and offal, should be given the attention which their importance demands. There is abundant opportunity for those interested in breeding pure bred geese to develop their stock along the lines indicated, and make for themselves a reputation which will bring its pecuniary reward, for the pure breeds will ever be the source from which those who wish to grow the most profitable market birds must obtain their stock.

As improvement must come through the selection of the best, and the constant culling out of those not up to a high standard of perfection, some means for the identification of individuals is necessary. The small breeder can readily distinguish each one by some characteristic, but even then it is well to have some permanent record which will serve to identify each member of the flock.

MARKING.

Metal leg bands of various forms and sizes can be readily obtained already stamped with numbers, and one can easily be fastened around the leg of a goose, and a record made of the number. Geese, however, frequently lose these metal bands, and it is generally safer to have a more permanent mark made by punching the web of one or both feet. For this purpose a belt or harness-maker's punch is used, cutting a hole about one-fourth inch in diameter, which does not so readily grow up as a smaller

one. In punching the web of the foot a piece of firm sole-leather is placed against the web, on the under side, to serve as a cushion for the cutting tube, and enable the operator to cut a smooth, round hole, with little pain or inconvenience to the goose. By holding the foot to the light the position of the principal blood-vessels can be readily seen and avoided in punching the web. Very little blood, however, is lost at any time, and the cut quickly heals. In fact the hole will often be completely closed by new growth, but a slightly thickened and perfectly smooth skin will cover the spot, so that the mark is permanent even if the hole closes up. Marked as above, geese are easily identified at any time, and when one attempts to keep individual records some such method of marking is indispensable.

CROSS BREEDING.

This term has sometimes been employed to define the use of a pure bred male upon females of mixed and uncertain breeding, the progeny of which is properly called a "*grade*," and continued use of males from the *same pure breed* with grades so produced is called "*grading up*." When wisely done, such a method is productive of excellent results at a very moderate cost. The use of pure bred sires from beef breeds in the herds of cattle on our western plains is a good illustration. Steers now get their growth and are ready for market at least a year younger than formerly, and furnish many more pounds of meat in the higher priced cuts in proportion to total weight. But a strict definition of the term "cross breeding" confines it to the *mating of animals of distinct breeds*, and therefore does not properly include such a course of breeding as has just been described and termed "grading up." The advantage of cross breeding lies in the fact that a first cross appears to possess characteristics which give it an advantage over either of the pure breeds from which it was derived. Warfield says:[1] "It has been well settled that such crosses are very fruitful in vigor

[1] Cattle Breeding. Warfield, page 190.

and vitality." This means a strong constitution and good appetite, which go far toward making a profitable animal. At various fat-stock shows the honors have been repeatedly secured by cross-bred animals, or the progeny of very high grades of one breed bred to another pure breed. Prizes so obtained testify to the ability of the crossbred to make a greater gain in weight in a less number of days than the pure bred. The good effect of crossing does not, as a rule, however, extend beyond the *first cross*, for when bred together general deterioration rapidly takes place. All that is gained in constitution and vigor in the first cross is quickly lost, and the progeny often varies greatly from the parents in size and shape, and frequently reverts to some ancestral and inferior type from which one or the other of the pure breeds was originally developed. The fine quality, size and vigor, of the first crosses is often a temptation to preserve them for breeding purposes, but disappointment is sure to follow such a course. Breed only from pure breeds, sending the crosses to market. Crosses may be "*graded up*" by using a male from one or the other of the pure breeds used in making the cross, but, as the results are usually inferior to those secured by a first cross, there is little purpose in doing so.

An English authority writes[1]: "I, myself, exhibited at Birmingham, some few years since, the cross between the male Embden and the Toulouse goose. * * The gander and two geese shown on that occasion, * * weighed sixty-seven pounds. They proved, however, unsuccessful as to prize taking; and the following season their progeny degenerated sadly, the unvarying result, as I have found, of all crossbred birds. * * All experiments, in fact, seem to limit the advantages of crossing the various breeds of geese to the produce of the first cross." Another writer says[2]: "I find that the cross between the English and Toulouse geese will produce much heavier and larger birds than either of the pure breeds. I have had the crossbred birds as heavy as 15

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[1] Hewitt, in The Poultry Book, Wingfield & Johnson, page 282.

[2] Parker, Ibid.

pounds each, at thirteen weeks old, and have no doubt that if a flock were properly managed they would be found to average 14 pounds at that age. At two and three years old they reach very nearly 30 pounds."

Wright says[1]: "I am convinced beyond question, after many trials, that the finest geese are those procurable from a cross between the Embden and Toulouse; and I much prefer the whole of the *geese* to be thoroughbred Embdens, and the *gander* an equally pure Toulouse. By this first cross, birds of great frame are procurable, and, under constant high feeding, of weights very far beyond those of either of the parents producing them. I have, as a rule, between Michaelmas and Christmas, killed birds of the same year thus bred, the geese being from 17 to 20 pounds each, and the ganders from 22 to 26 pounds. It must be kept in mind such goslings were *not* excessively fatted, as the weights might suggest to some persons, but, rather like Shropshire sheep, more remarkable for the immense quantity of flesh they carried than their obesity. The flavor of these cross-breeds is remarkably mild and fine. These first cross goslings must, however, *not* be retained as future *stock* birds, for they themselves produce young of very inferior size by throwing back (reversion). * * * The rule to be observed is, breed continuously (year after year) from the *same* old stock, which are purely descended, and kill off annually *all* the cross produce for table or market purposes. * * * It will be found much preferable for the gander to be a Toulouse and the geese Embdens than reversing the sexes, as they breed larger framed and *heavier-fleshed* birds, which is a most important feature." This cross produces heavy birds for Thanksgiving or Christmas, but is not so good for early maturity as a reverse mating would secure. Digby says[2]: "If you prefer breeding from a cross, let that cross be between two pure varieties. I would strongly advise you to use an Embden gander and Toulouse goose, or *vice versa*, but the Toulouse being very much more pro-

[1] The Illustrated Book of Poultry, Wright, page 562.

[2] Henry Digby, On Ducks, Geese and Turkeys, page 134.

lific layers than the Embdens, frequently lay double the number of eggs in a season; consequently they are the best and most profitable to keep for this purpose, and, as they do not evince a desire to sit nearly as soon as the Embdens, their eggs may be set under hens and double the quantity of goslings may be hatched and reared." While what the last writer says about the comparative sitting propensity of the two breeds is quite true, we think he has overestimated the laying capacity of the Toulouse as compared with the Embdens. For the past two years, at this Station, the Embdens have laid 71.5 per cent. as many eggs as the Toulouse, but the number laid by either breed has not been large, and it is quite possible, that with perfect liberty, egg production would be increased and the proportion changed. Of one other advantage in crossing we wish to speak. The Jews, as a race, are large consumers of geese, the fat supplying in some measure the place of lard, which they never use in cooking. For some reason, in purchasing geese in the market, they always look for a bird with a *yellow* or *orange bill,* and a large wholesale poultry dealer states that it is almost impossible to sell a Jew a black-billed goose so long as he can find one having a light colored bill. Now it is policy for the producer to cater to the requirements of the market—to produce what is wanted and put it on the market in the most attractive style—and if a yellow bill helps the sale of the stock at times, why not produce geese with light colored bills? The Africans and Brown China breeds have black bills; the other three breeds, orange or light colored bills. Now it is a rule, almost without exception, that a white or pied (particolored) goose always has an orange or yellow bill, sometimes, however, mottled with dark color. When Africans and Brown Chinas are crossed with Embdens, a large part of the progeny will be white or pied, and therefore have the light colored bill. An additional advantage is the fact that white birds dress easier and look better when dressed than dark birds. By crossing the Embden and African breeds we secure in the progeny a union of the good points of both breeds.

The cross-breeding of geese is a very simple and practical question as compared with the cross-breeding of fowls. In order that one may be provided with crossbred cockerels for market and crossbred pullets for laying stock, one must keep a large flock of pure bred females of one breed, and a suitable number of males from another. But as this pure bred stock must be renewed about once in two years, one is under the necessity of buying pure bred eggs or chickens, or of keeping breeding pens of two pure breeds in order to have the stock for the production of first crosses. No such difficulty is presented in the raising of crossbred geese, because the breeding stock is so long lived that it need seldom be replaced. Ganders and geese once mated may be kept seven or eight years without change, when it would usually be best to change the gander for a younger one of the same breed, although Canada ganders are useful for a very much longer time, in most cases, barring accidents, for twenty-five years at least.

THE GOOSE INDUSTRY IN RHODE ISLAND.

Compared with her sister States, Rhode Island is small in area, but so situated in relation to salt water that her coast line corresponds inversely with her size. In greatest length and width the State is about forty-eight by thirty-seven miles. The land area is about 1,054.6 square miles, and, including Narragansett bay, about 1,300 square miles, while the coast line, washed by tide-water, measures about 400 miles.[1] In addition to this extended coast line is a large area of landlocked ponds of brackish and fresh water along the whole southern shore, and numerous ponds, rivers, and streams throughout the State, which furnish ideal conditions for the keeping of geese. The State is famous for her poultry industries, and her turkeys have an established reputation in the best markets of the country. Her *green geese* and *mongrels* are no less favorably, but perhaps less widely, known, because restricted to narrower channels of trade. Geese are very hardy,

[1] R. I. State Census, 1885, page 2.

subject to no diseases and few enemies, excepting dogs and foxes, and, aside from the breeding season, require less care than cows, sheep, or hens, while the income from money invested is perhaps greater than any other farm industry can show. The following figures relating to geese and turkeys are compiled from the Rhode Island census, 1885:

	Number kept.	Value.	Average value.	Value of product.	Average annual product.	Per cent. gained.
Geese	8,677	$14,437	$1.66	$23,629	$2.72	163.
Turkeys	22,767	39,473	1 73	17,923	.78	45.

Had the money invested in turkeys in 1885 been invested in geese, and returned the same per cent. of gain as was obtained from those kept, the value of the product would have been $64,340.99, instead of the $17,923 received from the investment in turkeys.

The following statistics regarding the goose industry are kindly furnished in advance from the information secured by the census department of the State, and relate to the year ending with November 1st, 1895. Number of breeding geese kept in the State, 3,909; valued at $7,141.35, or an average of $1.82 each; 22,257 goslings were raised, valued at $26,039.50, an average of $1.17 each. The value of feathers sold was $418.20, and the number of pounds was 987, the average per pound being 42.3 cents. The total value of goslings and feathers was $26,457.70, making an average return of $6.76 for each breeding bird kept, or an increase represented by 371.42 per cent. The entire number of breeding geese kept in the State averaged to raise nearly 5.7 goslings each during the season. On November 1st, 1895, there were on hand 4,811 breeding geese, valued at $8,790.85, or 902 more geese than the year previous, worth $1,648.65 more than the breeding geese at that time. When these figures are compared with those of 1885, we find that the number of breeding geese had decreased 55 per cent., while better management or good luck, one or both, had increased

43

the product 11 per cent. beyond that of 1885. The income per goose in 1895 was $6.76, as compared with $2.72 ten years before, and if we represent the gain by percentage it was 163 per cent. in 1885, and 371.42 in 1895.

We are of the opinion that the income per goose in 1895 is higher than the income per sheep for the same year, but the data with which to prove the statement have not yet been published. In 1885 the census gives the number of sheep as 16,298, and the value of lambs as $24,587.00. The wool is valued at $16,453.00, or a total of $41,040.00. This gives an average product per sheep of $2.51, which is 21 cents less than the average value of the income per goose for the same year, and $4.25 less than the average income per goose in 1895.

One goose breeder[1] raised, one season, from four pairs of geese, 61 mongrels, which sold for $149. Another season he had 37 sheep, ewes, from which 37 lambs were raised and sold at $5 each. The same season 10 geese paid better and ate less. Rankin says[2]: "I am going to tell you of one experiment I made with a pair of African geese. I let them run separately, fed liberally, to see the best they could do. The goose laid 51 eggs, and I only succeeded in getting 37 goslings. A horse got loose and killed one, and one died, leaving me 35 for market. I sold them * * * for $81.47; so one goose gave me more profit than a cow and two hogs. Yet I did not feel satisfied with my hatch, which was under the average. One of my neighbors beat me."

The following comprehensive and complete account of the goose business, as conducted by one of the largest breeders in the State,[3] is based upon figures kindly furnished by him. The breeding stock kept, the number of goslings raised each year, the price at which they were sold, and the product per goose in goslings and cash, are given below.

[1] Mr. Carder Whaley.

[2] Rept. R. I. State Board of Agriculture, 1896, page 426.

[3] Mr. P. H. Wilbur. Upon the homestead farm of about 200 acres, on the Sakonnet river, in Little Compton, between 1,500 and 1,600 goslings were raised in 1897.

Year.	Total number geese kept.	Females.	Males.	Number of goslings sold.	Average price.	Total value.	Average product per goose kept.	
							No. of goslings.	Value.
1890....	57	....	... .	383	$1.185	$434.70	6.7+	$7.626
1891....	57	....	....	495	1.094	541.53	8.6+	9.500
1892....	57	....	....	425	1.150	488.75	7.4+	8.574
1893....	57	....	....	310	1.175	364.25	5.4+	6.390
1894....	75	56	19	235	.815	191.52	3.1+	2.553
1895....	68	52	16	450	1.250	562.50	6.6+	8.272
1896....	66	50	16	478	1.090	521.02	7.2+	7.894
1897....	66	50	16	482	1.240	597.68	7.3+	9.055
Average for eight years					$1.118+	....	6.5+	$7.483

In the fall of 1893 the entire breeding flock was sold, and a new flock purchased for the season of 1894, and the results that year, as compared with subsequent years, show clearly how much less can fairly be expected from young geese, in new quarters, than from those a little older and well established. The average product per goose for the eight years was $7.48.

FROM GROWER TO CONSUMER.

Aside from the limited number of those who grow *mongrel* geese, which are destined almost wholly for the Thanksgiving and Christmas trade, and which cannot be so well fattened until cold weather, comparatively few goose raisers fatten and market their own birds. The goslings are usually sold alive at the door to the agents of a few men engaged in the business of fattening and marketing green geese and other poultry. As high as $2.00 each for well grown, very early goslings, four weeks old, have been paid, but they are not usually sold until the long flight feathers of the wings have made sufficient growth to reach the tail, and they are nine or ten weeks old. If bred from good stock, and they have

had the run of a good pasture and some grain, they should weigh at that age 7 to 10 or more pounds, alive, and have well developed, fleshy bodies, which will make a good foundation for the fattening operation. The buyers do not care to have the goslings *fat*, much preferring to have a good sized, well grown body, produced by an abundance of nutritious green food and a moderate allowance of grain. The process of fattening and preparing for market will be described in the proper place in this report.

We believe that many more geese would be kept by farmers if better opportunities were provided for the sale of the young birds alive, as the operations of fattening, dressing and marketing are such that the breeder of a few goslings cannot economically do the work. Heretofore, the agents of the fatteners have confined their weekly trips to that section of Rhode Island which lies on the east side of Narragansett bay, where the greater number of the geese in the State are now kept. The town of Little Compton, in the southeast corner of the State, had, in 1885, breeding geese to the number of 3,261 out of a total of 8,677 kept in the State, or about 37.5 per cent. of the total number. The shore towns of Washington county are equally well situated for goose raising, but comparatively few are now kept. The following table is interesting as showing what might be done in these four shore towns. The figures are taken from the State census of 1885:

	No. of geese kept in 1885.	Total acreage.	No. acres per goose kept.	At 2.93 acres per goose there might be kept.
Little Compton....	3,261	9,581	2.93	3,261
Wash. County	......	......	.....	....
North Kingstown..	122	17,198	140.96	5,869
South Kingstown..	476	41,689	87.58	14,228
Charlestown	207	13,754	66.44	4,694
Westerly	131	16,622	126.88	5,673

The total number of geese kept in the four shore towns of Washington county in 1885 was only 936, yet every natural advantage is as good as in the town of Little Compton, which, though smaller in area than either of the towns mentioned, had 3,261 geese. What the farmers of Washington county or other parts of the State require, in order to successfully carry on the business of goose raising, is a *ready sale for the live goslings at the farm*, or some nearby point where they can be turned into cash when ready for fattening. We believe that to be the factor which has made goose raising on the east side of the bay so much more profitable than elsewhere in the State. Stimulated by the ready sale of the birds at a fair price, farmers have given attention to the conditions required to assure success, until the business is better understood there than elsewhere. We believe that with an equally good opportunity to dispose of the live goslings the residents in the four shore towns above mentioned would soon be as successful in the goose industry as those in Little Compton. In 1885 the four towns owned a total of 936 geese, and the total product from them, as stated in the census for that year, was $717, an average product per goose of only about 76 cents as compared with $2.72, the average for the State, or $3.79, the average product of each of the 3,261 geese kept in Little Compton. If the inhabitants of the four towns named entered into the business as extensively, and with the same degree of success as achieved by the farmers of Little Compton, the product of the industry would be of considerable importance. Little Compton had, in 1885, one goose to each 2.93 acres of area; at that rate there could be kept in the four shore towns of Washington county 30,464 breeding geese, and could they be made to yield the same value of increase per head, $3.79, as was obtained in Little Compton in 1885, the sum realized would be $115,458.56, a handsome addition to the agricultural receipts of the four towns. Is there anything impossible or improbable about these figures? We think not when we reflect that the average product per goose for the whole State, derived from the advance figures of the 1895 census, is $6.76. Some

one, however, may say that such a development of the business would glut the market with green geese, which would doubtless be quite true if it should take place in one year, but for evident reasons it could only come about gradually, and with proper effort the market for them could be greatly enlarged. A very few dealers in Boston and New York now receive about all the green geese put on the market by the only two parties at present engaged in the fattening business. Other cities and the summer resorts of New England would consume a large annual product when once made acquainted with the tender, delicious quality of a roast green goose. Its merits were doubtless appreciated in Shakespeare's time[1], and if more frequently met with in our markets, and more readily obtained, the demand for it in our time would, without question, largely increase.

SUITABLE LOCATION.

While a pond, brook or stream of water large enough to provide a permanent supply throughout the season makes the most desirable place for keeping geese, they are not entirely dependent upon it. Water may be supplied in tubs, or barrels, sunk in the ground during the breeding season, and through the fall and winter a supply of water in pails or shallow tubs to serve for drinking, will be quite sufficient. In the keeping of Canada geese, however, a natural body of water, pool, pond, or stream appears to be quite essential to successful breeding.

A colony of geese may often be confined in a field fenced with an ordinary stone wall. Fences, however, must be tight at the bottom, that they may find no openings through which to crawl, as they are much more likely to creep out than to fly over a fence or obstruction.

In many mild climates, where snow remains for only a short time on the ground, and where the temperature does not often go below zero, geese will frequently ignore any shelter whatever, re-

[1] Shakespeare's Love's Labor's Lost, IV-3-75.

quiring only barrels or boxes in which to make their nests. It is always well, however, to have some shelter, as an open shed or cellar, into which they can go in the severest weather. A rough shelter of poles, thatched with straw, and provided with a bed of dry straw, serves a good purpose, and is all that they require. A comfortable shelter in the most severe weather of winter will doubtless help to increase the egg production later in the season.

No kind of poultry keeping can be carried on at so little expense for buildings and equipment as goose raising, because of the hardiness of the birds, and their desire to remain in the open air. Geese dislike confinement, and the successful breeder endeavors to so locate his colonies of geese as to have them realize their confinement as little as possible. The more freedom they have, the better they are likely to thrive.

A piece of low swampy ground in which pond holes exist, or may be artificially made, is an excellent place for geese, and when a piece of dry upland can be also utilized for the same flock, it makes an ideal location. The geese delight to rest on a sunny side-hill after their swim and exploration of the pond or brook. The short green grass of the upland is also relished by them, and promotes more rapid growth than the coarser and less nutritious grasses of the swamp.

Having the location, the next thing to be considered is the breeding stock and

MATING.

The first question to be determined by the breeder is whether he will keep and raise pure bred or cross-bred geese. There is always some demand for breeding stock, which should always be pure bred, even when cross-breeding for market is followed. Some breeders contend that even for market it is better to breed pure bred geese, than to cross-breed. There are good reasons already given in favor of cross breeding, where only green goslings or birds for the market are to be produced. A man who raises pure bred birds for breeding stock has often to keep them for

some time, with the uncertainty of sale, while green goslings are always disposed of in the course of three months, and other market stock before the close of the year. So few geese, aside from those intended for use as breeding stock, are kept into the winter by those who grow them, that it is often difficult to obtain good birds for breeding, unless they are ordered during the summer season before the young geese are killed. It is oftentimes a difficult matter to purchase desirable breeding stock aside from young geese. Few men, having geese well mated which have proven good layers of fertile eggs, care to sell them for any price which the purchaser would deem reasonable. A man beginning goose breeding is more than likely to get undesirable stock when buying old geese, and it is much the safer way to purchase young birds, and take time enough for them to get accustomed to the locality, and to get of sufficient age to show what they are really capable of doing, before expecting the best results from them. A goose two or three years old is undoubtedly better than a young goose, as she will lay more and larger eggs, and the young will usually be more vigorous.

Old geese, changed from their home surroundings to a new locality, will seldom do as well the first season as afterwards, unless, perhaps, the change has been made in the summer, after the close of the breeding season; so that, in any event, the novice in goose breeding must not expect the best results the first year. He must determine to begin and follow the industry with patience, acquiring experience, and getting his stock into the best possible condition at the same time. Success will come, if care and patience are exercised.

Having determined upon the breed or breeds which are to be kept, secure well developed, perfectly formed, healthy, vigorous stock, and it is well to get the geese from one breeder and the gander from another, who has an entirely different strain of stock, so that the two shall be entirely unrelated. One should not forget that in buying breeding stock he is purchasing for several years to come; it will therefore pay to exercise care in the choice of

stock. Let the birds be as nearly perfect specimens of their breed and type as can be obtained. Secure, if possible, those from good laying stock, as there is great difference in regard to the egg production in different strains of the same breed. The number of eggs laid by a goose measures, to a large extent, the profit obtained from her keeping.

Three geese to one gander of the common domestic breeds is about the right proportion. In breeding mongrel geese, where the wild gander is mated to a domestic goose, there must be as many ganders as geese. By arranging with some goose breeder at the early part of the season—May or June—breeding stock can be selected from the number raised during the season, and in that way better birds obtained than later in the season. If neglected at this time, the birds may all be sold as green geese, and later, when one wishes to buy breeding stock, it cannot be obtained.

If the young geese can be brought to their new home in the autumn they will become well accustomed to their surroundings and feel quite at home before spring, and there will usually be no difficulty in mating.

If, for any reason, it is desirable to separate birds already mated, they should be removed from each other's company, and so far removed that they cannot hear one another. Any changes in the mating of geese should be made in the fall, or certainly before January, if the best results are expected.

More care is necessary, and more difficulty is experienced, in the mating of wild than domestic geese. We have heard the following course of procedure given where it was desirable to remove a goose from a wild gander and substitute another for a mate toward the beginning of the breeding season. The goose and gander are first confined in a yard for a little time; the gander is then removed to such a distance that he cannot hear the sound of his mate's voice; the new goose is then confined in the pen with the old goose—the former mate of the wild gander. They are kept together for perhaps two weeks, until they become accustomed to each other and the new goose learns the notes of the old one.

44

After two or three weeks the old goose is removed entirely out of sight and hearing, and the wild gander is returned to the pen. He will generally accept his new mate after a little time.

HANDLING.

Breeding geese should not be frightened or disturbed, and the feeder should always treat them kindly and be on the best of terms with them. The more gentle and tame they are, the more profitable they are likely to be.

In handling a goose it should always be taken by the neck, and when lifted from the ground the body should be turned with the back toward the person handling it. In that position it cannot strike, and will remain quiet and docile. The body can be partly supported by seizing the first joint of the wing with one hand. If the goose is held facing one, it will strike hard blows with its wings, or scratch with its feet.

BUILDINGS AND CARE.

Having obtained the breeding stock, each colony, consisting of a gander and one to three geese, should be given a location. This may be a yard 60 to 100 feet square, the larger the better; and if so arranged as to form part of a pasture, or large lot, where the geese can wander without damage to crops or grounds, so much the better. They should be allowed to think that they are not confined, if possible.

If heavy snows or extreme cold weather are liable to prevail, a small, partially open shed, six feet by eight, or larger, is desirable for shelter. This can be provided with dry litter, which will furnish them a comfortable place in case of severe or inclement weather. In any ordinary weather, they will prefer to stay out of doors, and even on a snow bank, to remaining in the building; but if accustomed to the shed, they will utilize it when the weather becomes severe, and it may save them from having their feet frost-bitten, which usually results in lameness.

Boxes or large barrels make good nests, and should be supplied

by February 1st, as geese are quite apt to continue laying in the place which they select for depositing the first eggs. The nests should contain a sufficient quantity of cut straw or other material for comfort and to protect the eggs. It is better to have nests enough so that each goose can have one, as it is more convenient when they want to sit.

It is better for the colony during the breeding season, and more of the eggs are likely to prove fertile, if they can have daily access to a pond or brook of water in which they can swim, but if such a place is not available, a large half barrel, sunk in the ground so that its top is on a level with the surface, will answer the purpose. If the barrel is deep, it is well to put into it, at one side, a flat stone, reaching within five or six inches of the top, upon which the geese can step in getting out. This is particularly important if the barrel remains in the yard after goslings hatch, as they frequently drown from getting into barrels or tubs where they are not able to get out.

If possible, they should have opportunity to roam in the pasture or field, so as to get some exercise, and, as the season advances, pick up some grass and green food. This exercise helps not only to stimulate the egg production, but a larger proportion of the eggs are more likely to be fertile.

A goose usually covers her eggs whenever possible, and they will be found buried in the straw in the nests. When geese are laying in cold weather, the eggs should be gathered frequently to guard against their becoming chilled; as they frequently lay during the night, it is almost impossible to prevent some from getting too cold.

Where more than one colony is kept, they may be located a little distance apart, and each colony should be fed on its own grounds and taught to recognize that spot as its home. The ganders may occasionally meet and have a battle, but on such occasions there is usually such a commotion and confusion of voices that the owner can soon separate the combatants, and they return, each with his flock, to his own domain.

For the best results, especially in the breeding of thoroughbreds, each colony should be lettered or numbered, so that a record may be kept of the laying qualities and fertility of the eggs of each bird. This is not a difficult matter when nests enough are furnished so that each goose has her own, and is taught to lay in it. The eggs when gathered can be marked with the name and letter of the colony, and the number of the goose; also the date. In this way it is possible at the end of the season to tell how many eggs each goose has laid, and the date enables one to always guard against keeping the eggs too long before setting. Carefully kept records of the number of eggs produced by the various birds kept will enable one to select for future breeding stock only descendants of good layers of fertile eggs, and, where this system of selection is followed for a series of years, considerable improvement in the stock results.

FEEDING AND MANAGEMENT.

After the breeding season, during the summer and fall, geese can obtain a sufficient living upon good pasture provided with never failing water. The flock can be placed upon the grain stubbles, or in meadows after the hay has been cut, and will pick up from the field many injurious insects or scattered grain. They have been observed to be fond of the army-worm, of which they devour large numbers when they have an opportunity. They will eat large quantities of windfall apples, and where sufficient numbers are kept in an orchard, will keep the ground as free from fallen fruit as a flock of sheep. The benefit to the orchard by the destruction of insects and larvæ in this way is difficult to estimate. The late windfalls and second-class apples can be gathered and used later in the season for feeding to geese with good results. They eat them raw, without cutting, unless extremely hard.

As cold weather approaches, geese for the Thanksgiving or Christmas market should be shut up and fattened. The breeding geese should receive some grain, but not sufficient in quantity to

cause them to become too fat. Turnips, beets, or potatoes may be boiled and mixed with wheat bran, and a little Indian meal for the morning feed. At night, whole grain, oats, wheat, barley, or corn may be fed to them. It is better that not more than one-third of the whole grain fed at night should be Indian corn.

When the ground is covered with snow, so that no grass can be obtained, a few cabbage leaves, apples, or a sugar beet cut in two, are relished by them. They should always be provided with drinking water, which may be given to them in a butter tub or pail. Unless the soil of the pen where they are confined is gravelly, a heap of sand or gravel in the yard is appreciated by the geese. Oyster shells should also be provided, and a piece of rotten wood or an old stump gives them a great deal of pleasure and amusement; they will bite off and eat every portion that is sufficiently decayed to be separated from the rest.

Too early laying is not desirable, as goose breeders generally do not care to have many goslings hatched before grass begins to start in the spring. It is quite difficult to properly care for goslings unless they can have access to tender grass, therefore February or March is considered sufficiently early for geese to lay. Feeding has considerable influence upon the production of eggs, and from November to February 1st geese should be fed a sufficient quantity and variety of food to keep them in good health and a thrifty condition without stimulating egg production. After February 1st a little more food, of a little better quality, can be supplied. Some beef scraps two or three times a week may be mixed with the morning feed, and a little gluten meal or ground oats will also improve the quality of the mash.

At this time, the more freedom they can have the better, as it gives them exercise, and access to a small pond, brook, or spring hole, gives the best possible accommodation for them. If no pond hole or body of water is accessible, the large half barrel or tub sunk in the ground in the yard and kept filled with water should not be forgotten.

The amount of green food or roots, the variety and quality of

the grain food given, with attention to a proper supply of shells and grit, will largely influence egg production.

Most breeds of geese lay frequently from 10 to 20 eggs, when they want to sit. After a goose has been a day or two on the nest, she can be taken off and put in a coop, which should be large enough so that she can stand erect. If she is confined here, at a little distance from her mates, she will usually abandon the idea of sitting after five or seven days, and when released will shortly begin laying again. Some breeders make a practice of allowing the geese to sit at the end of the second litter, while others break them up again, and usually obtain a third litter of eggs. The number of eggs laid, however, in the second litter, is usually smaller than at first, and less are usually laid in the third litter than in the second. Toulouse geese are less likely to become broody, and sometimes they will not manifest any desire whatever to sit. When each goose has her own nest, she can easily be set at the end of the second or third litter, as desired. At this time the goose plucks off more or less down from her breast, with which to line the nest and cover the eggs whenever she leaves them. It is better that one person should care for the geese regularly, and he should be quiet and gentle in his movements, so as to gain the confidence of the flock and make them as tame as possible. The advantage of this will be evident when the geese wish to sit, during incubation, and while the goslings are small. A quiet, docile goose does better than a shy one.

CARE OF EGGS, AND HATCHING.

The eggs should be gathered as soon after they are laid as possible, to avoid their being chilled. They should be kept in a moderately warm place, not too dry, and should be turned over every day until set. It is well to mark the date upon the shell of each egg as laid, and, as before stated, also the number of the colony, and the name or number of the goose which laid it, if possible; in setting eggs, one can then pick out those first laid. The

sooner they are set after being laid the better, but they may be kept several weeks. Usually, however, the vitality is somewhat affected by long keeping, and the goslings are not so strong and active as when hatched from fresh laid eggs.

Hens are generally used to hatch the first eggs, and for this purpose quite large hens, as Brahmas or Cochins, are generally preferred. Five to seven eggs, according to the size of the hen, are enough, as they require considerable heat, and should be well covered. Ducks are sometimes employed to hatch goose eggs, and will cover seven to nine eggs. Turkeys will hatch goose eggs nicely, but are rarely used for that purpose. Geese are generally allowed to sit on a part of the second or third litters laid. A goose is usually given eleven eggs for a sitting, although a very large one might cover thirteen. A goose covers the eggs with the downy feathers, with which she has lined the nest, whenever she leaves it to feed or bathe. The ganders should be left with the geese during incubation. They will remain near the nest of their favorite and courageously defend her from any intrusion. Children should never be allowed to approach them at such a time, as they are capable of inflicting serious injury. Eggs can be successfully hatched in incubators, but most of the breeders in this State set the eggs under hens or geese.

Some breeders wash the eggs if covered with mud, while others do not. If the nests of the geese are properly provided with straw, the eggs will never be sufficiently soiled to require washing. A basement, or a fairly close building, where a reasonably mild and uniform temperature can be maintained, makes an excellent place for setting hens on goose eggs. After the eggs have been incubated for about seven to ten days they can be tested, and the infertile ones taken out. The fertile ones can then be all placed under a part of the hens, if several have been set at one time, and fresh eggs placed under the others. The infertile eggs will be found to be as good for use in cooking as fresh eggs. The shells and lining membranes of goose eggs are thicker and tougher than those of hens' eggs, and care has to be exercised

that they do not become too dry. Sprinkling the floor will help to keep the air of the place moist, and many breeders sprinkle the eggs and nest during the last two weeks of incubation, and still others dip the eggs into water instead of sprinkling them. Some use luke-warm water, others use cold water. Eggs under a goose, however, seldom need attention, as more or less moisture is brought to the nest when the goose bathes, as she will at intervals, if allowed the opportunity. It is well to place food and water near the nest of the sitting goose at hatching time, so that she will be less likely to leave her nest before all the goslings are hatched. The fertile eggs usually hatch at the end of 28 or 30 days, but a longer time is occasionally required. Eggs have been hatched on the fortieth day of incubation.

GOSLINGS: CARE AND FEEDING.

The very early goslings are more valuable than those later hatched, because they mature earlier, and are the first to be ready for market. If hatched before the grass starts in the spring their care is rather a difficult matter. They require to be kept indoors, and on an earth floor, if possible, and should be provided with some kind of green food, as chopped lettuce or cabbage. Oats may be sown in shallow boxes of earth, and their tender blades make a good substitute for grass. As a rule, however, goose breeders calculate to have the first goslings hatched about the time grass begins to grow in the spring and the weather becomes sufficiently mild to allow the young goslings to be put out of doors. When hatched they do not require feeding until they are 24 or 36 hours old. The goose will take excellent care of her young brood, and need not be disturbed until time to feed them. Some hens, however, become restless on the nest, and are liable to kill the young goslings by treading upon them. In such cases it is well to give the goslings to a more quiet hen, or perhaps remove them to a wool-lined basket or box by the kitchen fire, where they can remain during the day, to be returned to the hen at night.

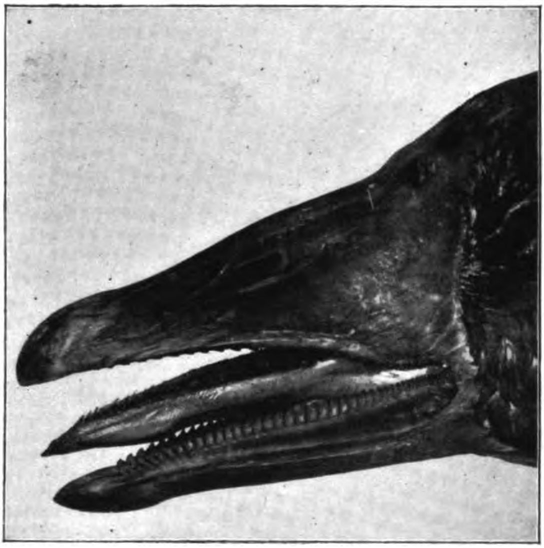

Fig. 9.

From a photograph of the bill of a goose, showing the serrated edges of both the upper and lower mandible and the rough covering of the point of the tongue, which enables it to graze as easily as any ruminant.

A good feed for young goslings is scalded, finely cracked Indian corn, with a little sweet Indian meal or bran mixed with it. It should not be wet and sticky, but just enough water should be added to make the dough have a crumbly consistency. Northern flint corn, finely cracked, is preferred by some feeders. At the end of 24 or 36 hours they may be removed from the nest and fed. Water should be provided in a shallow dish, in which a few pebbles or bits of coal have been placed, or some other provision made to prevent the young goslings from getting into the water, and getting the soft down, with which they are covered, wet, thereby becoming chilled. Sharp sand, saturated with water, should be provided in another shallow dish, where they can help themselves at any time. While small they should be fed four or five times a day, and when ten days old a little food may be put into the building when they are shut up for the night. Do not overfeed. Grass is the natural food of goslings, and where the supply is abundant less grain food is required. If, however, the supply of grass or green food is scanty, they should be fed more frequently and a larger quantity, as goslings to be profitable must be kept growing from the time they are hatched until sold. One point should be remembered—the water dish should never be allowed to become empty for any length of time, either while the goslings are small or at any time during their life.

If the weather is pleasant they should be given every opportunity to feed upon short, tender grass, and, if kept indoors by severe storms, a few sods or bunches of short grass will be greedily accepted. Goslings with a goose may be confined by three boards, ten or twelve feet in length, and a foot wide, set upon edge, making a triangular pen. This pen can be moved as frequently as the goslings eat up the grass and require a new pasture. The old goose will seldom cause any trouble by deserting her goslings. She should be placed a little distance from other geese, and especially her mates, or they may cause trouble by jumping into the pen with her, to the great danger of the goslings. When goslings are with a hen they should be given the same opportunity to feed

upon tender grass, which promotes their growth more rapidly than anything else. The hen, however, will easily jump out of the board pen already described, and should be confined in a slat coop within the pen, or may be tethered by a string attached to one leg, and fastened by a pin to the ground. The board pen should surround the coop or spot where the hen is tethered, to prevent the young goslings from wandering too far during the first few days of their lives. A smooth, hard cord, like a coarse fish-line, with a brass swivel, such as is used in some kinds of fishing tackle, makes an excellent tether. A strip of cloth, half an inch wide, can be securely fastened around the leg of the hen to which the cord is attached. The swivel will prevent any knotting or twisting of the cord. These swivels can be obtained for a small sum from wholesale dealers in fishing tackle. At first the cord should not be long enough to allow the hen to get out of the pen. As the pen is enlarged or removed she may be given more liberty. As the goslings grow, care should be taken to provide them with plenty of fresh grass by frequently moving the pen, or giving them larger pasture ground. After they are ten days old, the goose and her flock can be allowed to roam at will in a pasture with short grass, although it is better that the goslings do not have an opportunity to swim, as they are liable to become chilled by the cold water. They should be protected from storms or from sudden showers. For this purpose a large box may be kept near the pen in which they can be confined. Goslings, while small, are covered with down, which seems to have little power to shed water, and soon becomes wet, and the goslings become chilled and soon die, unless thoroughly dried and warmed. They should also be confined at night where they are safe from the attack of rats, weasels or minks. The box or building in which they are confined should be provided with a sufficient supply of cut straw or hay to cover the floor, and this should be frequently changed. It is better to give a fresh supply every day, as the bedding soon becomes soiled and wet, and young goslings are liable to contract rheumatism from sleeping upon it.

When goslings are hatched in incubators they can be readily cared for by using some good artificial brooder, such as "Peep o' Day," or some other equally good one. The brooder should be so arranged as to give plenty of fresh air, and yet provide a warm place where the goslings can run when chilled. Care should be taken not to overcrowd the incubator, boxes, or pens where goslings are confined, as by crowding they are liable to injure or even kill one another. The first day or two, the incubator should have a temperature of 90 to 93, which may soon drop to 80 or 85, according to the weather conditions. At the end of two or three weeks, and much less time than that after June 1st, the brooder can be dispensed with altogether. The brooder should be so located that the goslings can have a good run on tender grass. Wire netting, one foot wide and one inch mesh, makes a good fence. This can be held in place by small sticks, and while the goslings are quite small the pen should be placed rather near to the brooder. The bottom of the brooder should be covered with fine sand, which should be frequently changed so that it may be dry and clean. However goslings are cared for, the shallow dish of sharp sand saturated with water, and the water supply so guarded as to prevent the goslings from getting themselves wet, should be kept within their reach all the time.

Goslings occasionally get "cast." That is, they fall upon their backs by accident, and are unable to get up. A goose at such a time has sufficient instinct to turn the gosling over with her bill, but the hen fails to comprehend the necessity of this, and it is always well for the attendant to count his goslings at every feeding-time, when, if one is missing, it may, perhaps, be found alive and returned to the flock.

In extremely hot weather, or in the bright sunshine, goslings are liable to become sun-struck, and should be provided with shade from the heat of the sun. The box in which they are confined at night will serve for this purpose if it stands with the open side towards the north. When goslings are confined in a brooder, shelter may be provided by placing a box in the yard, or shade

may be given by laying two or three boards on some low boxes so that the goslings may run under them. As the goslings increase in size they should be given larger liberty, and the better the pasture, the more rapid the growth. After four or five weeks old, feeding at morning and at night will prove sufficient. Some breeders use a few sweet beef scraps in the food at this time, which may be composed of soaked cracked corn and meal in equal proportions, seasoned with a little salt. This food may be varied with whole grain—as a little wheat or corn—as they grow older. When penned up at night, some green oats, Dwarf Essex rape, kale, sweet corn, or sorghum may be put in the pen, and will usually be eaten up before morning. If the supply of tender grass is scanty, fodder crops like those above enumerated may be grown and supplied to the goslings several times during the day, or the flock may be hurdled upon small areas of these growing crops by use of wire fences. If frequently changed from one part of the field of oats or rape, to another, the ground can be repeatedly pastured as new growth takes place, and a good many goslings fed upon a comparatively small area.

As the weather becomes warm they can be allowed free access to water, in which they can swim if they choose, without danger of getting chilled. As soon as the quill feathers have developed upon their backs, the goslings will be out of danger from injury through getting wet in showers or storms. And when the flight feathers of the wings have grown sufficiently to reach nearly to the tail, the goslings are ready to sell to the fattener or to be penned up for fattening.

The important points in the successful rearing of goslings are: Not to overcrowd when penned together; to protect from severe storms or showers; from the excessive heat of the sun by day and from damp floors by night. With attention to these points, one is almost certain to rear all, or nearly all of the goslings hatched, for no class of young domestic poultry is as hardy, vigorous, and free from disease, as the gosling.

FATTENING.

Geese for fattening should be penned upon high, gravelly soil, or land that will not become muddy in wet weather. A pen for fifty geese should be perhaps 40 feet or more square, and should be bare of green crops, and provided with some shelter from the sun. A good shelter may be made by putting four crotched posts in the ground, upon which rails can be laid covered with white birches or boards. These may be fastened down so that a high wind will not blow them off and injure the geese in the pen. A wire fence, four or six feet high, is suitable for the sides of the pen. In fattening goslings during the warm weather of summer, provisions should be made for as much air as possible. If the weather is warm they eat less, and consequently fatten more slowly. When the weather is cool they fatten more rapidly. When penned up for fattening they may be fed for one or two days quite moderately, in a way to prepare them for the regular fattening ration. During this time they can have a little green food, and such grain food as they have been accustomed to. For fattening, they should be fed upon scalded dough, made from Indian corn meal and sweet beef scraps. Water should be provided in pails or buckets, giving them a fresh supply three times daily, but only sufficient for them to drink, and not enough for them to attempt to bathe, as water spilled around the pen is apt to make the ground muddy, and any unnecessary exercise is a hindrance to fattening. It is better to have two pails, each half full of water, than one filled to the top. Goslings can then only get water for drinking, which is all that is desired. Care should be taken that the scalded food is always sweet, and does not stand long enough to become sour and unwholesome. It should be scalded just long enough before wanted for feeding to become entirely cooled. The corn meal and the beef scraps should be of the very best quality, and mixed in the proportion of one part of scraps to four parts of meal, by measure, and a little salt should be added, just enough to season it, care being taken not to use too

much. A wooden "feed trough" about four feet long, and some eighteen inches wide and deep, with flaring sides, is most convenient for mixing. A common iron spade is used as a mixer. Enough *boiling* water should be used to swell the grain and leave it moist and crumbly, but not wet when cold. Feed in the morning what dough the goslings will eat up in an hour after feeding. At noon feed whole corn in the same way, but at night a considerable larger quantity of dough can be given them, as they will eat more sometimes during the night, when the weather is cooler, than during the whole day. A little powdered charcoal should be mixed with the dough about twice a week. Pieces of board, with a strip nailed on the edge, make good troughs in which to feed them. If at any time more dough should be given them than they eat up, it should be removed from the pen before giving them a fresh supply.

White flint corn or white corn meal is prized by some, who believe that it produces a whiter flesh or fat, which gives the bird a more desirable appearance. In Europe finely ground oats or barley mixed with milk is used for fattening, and thought to have the same effect on the color of the fat formed. No green food is given after the first day or two. They should have a constant supply of gravel, crushed oyster shells, and broken charcoal. The latter is especially desirable on the score of health, and it is also thought to assist in obtaining a white fat, so desirable for the market. Decayed stumps, or pieces of partially rotted wood, are greedily eaten by geese when fattening, and a moderate supply seems to do them good. It requires usually from seventeen to twenty days' steady feeding to fatten goslings. If fed much longer than that their appetites are likely to fail, and they are also inclined to moult, which of course seriously interferes with fattening, and would also make the bird hard to pick and unsatisfactory when dressed. Any goslings which are not fat when taken from the fattening pen are usually allowed to run outside for a week or two, where they have plenty of green food and only a moderate amount of grain, and are afterward put through the fattening pro-

cess a second time. Some fatteners, about two hours before killing the birds, allow them to eat what they will readily consume of sweet, fresh, green food, like green oats, or sweet corn. They claim that this fills the birds up, and they present a more plump appearance and sell better in the market. Goslings should be slaughtered when taken from the fattening pen, or soon afterward. They should never be shipped or carted away from the place alive. If this is done and they are then dressed, the fat will have a dark appearance, as though the birds were not in a good, healthy condition, and they will hardly be salable. If fat at the time of shipping or carting, they should be pastured upon grass until the dark fat has been absorbed, when they should be again fattened for killing.

No shelter from rain is required in the fattening pen during the summer or fall weather, and geese are almost never fattened for market during the winter. Geese intended for market are now usually fattened and killed not later than the middle of November, at which time the dealers put large quantities in cold storage for the winter and spring trade. One large dealer writes that when real cold weather arrives the flesh and muscles of both sexes rapidly harden and become tough, so that, when kept into the winter and then killed, they do not give satisfaction to the consumer. Goslings hatched in July and kept until January or February, and then fattened and put on the market, will be classed by the dealers as old geese, and bring a very inferior price. Since the almost universal use of cold storage, some dealers are having even their mongrel geese for the Christmas trade fattened and killed at Thanksgiving and kept a month in cold storage, instead of having them killed at Christmas as was formerly their custom. Goslings, while being fattened, should be kept as quiet as possible. They should not be disturbed by the presence of strangers or dogs. It is well to have the same person feed them regularly, as they get accustomed to him and expect their food at certain times. The attendant should be very quiet and moderate in his movements about the yards. Some kinds of geese are more nervous

when confined in the fattening pens than others, and at times a flock will get in the habit of running from side to side of the pen, or "churning," as the fatteners term it, when the least unusual thing occurs. Under such circumstances they fatten very indifferently. Several hundreds may be fattened in a pen together, provided it is sufficiently large for them, and that proper care is exercised in distributing the food and water so that all can share alike.

KILLING AND PICKING.

Young geese should be well fed the night before they are to be killed for market, and as before stated, some fatteners feed freely of some sweet green food, like green oats or sweet corn, about two or three hours before killing. The room to be used for dressing geese should be provided with a box to receive the feathers, at which two pickers can conveniently sit, one on each side. The box should be about twenty inches high, and perhaps two feet wide. A board across one end of the box makes a convenient place for a pail of water, used frequently by the pickers for wetting the hand. For killing, a stout knife with a double edged blade about four inches long, tapering to a point something the shape of a dagger blade, is commonly used. Everything being prepared, a number of goslings can be caught and placed in boxes convenient to the picking room. The bird to be killed is taken by the operator and held between his knees, the head resting in the left hand; a firm cross cut is then made in the upper and back part of the mouth, severing the main arteries of the head. The bird is then taken by the legs, and a quick, sharp blow on the head with a flat paddle, made from some hard wood, stuns the bird. Picking begins immediately. The operator sits in a chair beside the box, with the bird, back down, across his knees, the head being firmly held between the knee and the side of the box. The feathers are first removed from the under part of the bird, beginning at the abdomen and working toward the breast. All the feathers should be removed as the work progresses, excepting

possibly a few pin-feathers, which will have to be taken out later with a knife. The down can be best removed by wetting the hand and passing it quickly over the skin of the bird. Care should be taken not to tear the flesh, as the skin of some goslings is very tender. Birds with dark feathers, particularly of Brown China, and sometimes of African blood, pick harder and tear more easily than Embden or other white-feathered varieties. The feathers should be picked from the lower third of the neck, leaving about two-thirds of the length of the neck next to the head unpicked. The wing feathers beyond the first joint are also left, and in picking mongrel geese the tail feathers should also be left on the bird. When many pin-feathers are found on the birds, they have to be removed with a sharp knife. White pin-feathers can be shaved off, as the part remaining in the skin will not show, but black pin-feathers must be removed entirely. The operator takes the skin of the bird between the fingers of the left hand and makes a slight longitudinal cut in the skin on the side of the pin-feather, when it can be easily removed. A common shoe-knife is most convenient for this purpose, and should be kept very sharp, as a razor edge is necessary to do quick and satisfactory work. Removing the pin-feathers one by one is, of course, a slow process, but it has to be done that the birds may present a good appearance. In picking, only the salable feathers are put into the box, the wing and tail feathers and any soft pin-feathers being thrown upon the floor. Professional pickers usually receive ten cents each for picking green geese.

As soon as the bird is picked the blood is rinsed from the head and mouth, the bird is placed upon its back, and a string tied tightly around the middle of the body, pressing the wings firmly against the sides. Fairly stout, white cotton twine is generally used for this purpose, but mongrel geese, for the Christmas trade, are sometimes tied with a narrow, colored tape, or braid, which adds somewhat to the appearance of birds designed for a fancy trade. Appearance has much to do with the selling value of geese, as well as of any product put upon the market.

The wings are pressed slightly toward the back in tying, and their natural elasticity forces the breast meat and fat upwards so that the bird looks plump, if well dressed and the cord is tight.

Some fatteners break down the breast-bone before tying. To do this the bird is laid on its back on a solid bench, the breast is covered with several thicknesses of damp cloth, and two or three blows on the breast-bone given with a wooden paddle made from a piece of smooth oak board, about an inch thick and perhaps six inches wide. Just enough force should be used to crush down the rib bones, so as to settle the breast-bone down somewhat, the object being to give the breast a plump, meaty appearance. After the wings are closely tied against the body, and the blood has been rinsed from the head, the bird is immersed in ice water, barrels usually being provided for this purpose. In warm weather, when green goslings are usually dressed, they are kept in these barrels of ice and water until sent to market. The birds should be freshly packed in ice and clean water as soon as the bodily heat is thoroughly taken out of them.

They are shipped to market by packing in boxes or barrels with broken ice. The quantity of ice used depends upon the temperature of the weather at the time and the distance to which they have to be shipped. Before packing, the goslings should be removed from the barrels of ice water and laid upon boards or benches to allow the water to drain from them. In packing, the head of the gosling is placed against the side of the bird, which is then packed back downward on a layer of cracked ice in the box or barrel. After enough have been packed to make a layer, cracked ice is put in and another layer placed upon them until the package is full. Sugar barrels are often used for shipping. One or two holes should be bored in the bottom to allow surplus water to drain away. A good layer of ice should be used at the top of the barrel, which can then be covered with two or three thicknesses of burlap.

Green goslings are never drawn for market. The shrinkage in dressing is comparatively small, as only the blood and feathers are

lost. It occasionally happens that a specimen will absorb sufficient ice water so that the dressed weight will equal the live weight of the bird. As a rule, however, the shrinkage is about five per cent. of the live weight. Expert pickers can dress from twenty to thirty birds in a day, depending, of course, upon whether they are hard or easy to pick.

The feathers should be spread in some clean, dry, airy place to cure. If placed upon the floor of a loft they should be turned over with a fork every few days, until thoroughly dried. If put in bags and well steamed they are more valuable, as the steam in a measure purifies them and removes somewhat of the oily odor which they otherwise have. The feathers from a mature gosling will weigh about one-fourth to one-third of a pound, but green goslings, if quite young, do not yield as many feathers. The feathers from forty-five green geese, dressed August 29th, weighed twelve and three-quarters pounds after thorough steaming and drying. Where large numbers of green goslings are dressed, the feathers form no inconsiderable part of the income from fattening. The feathers alone form quite a source of profit, although their value is not as great as formerly.

Practically all the geese sold in Boston and New York markets are dry picked, but for some markets scalding is practiced. In that case the birds are dipped quickly into hot water, sometimes alternating the dipping with cold water, and the birds while moist with the hot water are wrapped tightly for a few moments in cloth. The operation must be carefully done, so that the heat will loosen the feathers and yet not scald the skin so that it will break in picking. Experience is required to perform the operation successfully. Where birds are scalded all the feathers are removed, including those on the neck and wings left on when the bird is dry picked. This allows the housewife to use the whole neck and wings in cooking, so that the shrinkage in drawing would be a little less from this method of picking than from dry picking. Scalding is seldom practiced where birds are to be shipped and kept for some time before being sold; but where birds

are slaughtered for immediate sale in a nearby market, the picking is made very easy by scalding. The feathers, however, are of no value.

THE PRODUCTION OF MONGRELS.

The Canada goose, mated with the domestic goose, produces goslings commonly called mongrels, and sometimes termed "mules," because of the fact that they are sterile. It is occasionally true that a mongrel goose when kept for two or more years will lay a few eggs, but we have no knowledge that goslings have ever been hatched from eggs laid by a mongrel goose. The progeny of the cross mating is usually sold the same season it is produced, and because of its delicacy, brings a much higher price in the market than other domestic water-fowl. As the Canada females lay but few eggs, it is not customary to raise mongrels from them. They are more often used for breeding pure Canada geese. The mongrel is generally the product of the Canada gander mated with some dark colored domestic goose, usually an African or Toulouse. The gander will mate equally well with a white or light colored goose, but the progeny would be very liable to be marked with more or less light colored feathers, which might cause doubt upon the part of the dealer as to the genuineness of the breeding, and thus injure the sale when the bird came to be marketed. The gander has usually to be kept until two or three years old before he will mate, and probably for this reason the ganders bring a comparatively high price, good breeding birds ranging from ten to fifty dollars or more each. When a gander has reached the proper age for mating, a good sized, well bred African or Toulouse goose is usually selected for his mate. A goose two or three years old, which has already proven to be a satisfactory egg producer and good mother, is preferred, and the two should be confined together in some roomy yard provided with water and grass. It is better to get them mated during the autumn months, and to confine them in the field or yard which is to be their future home. This should contain a natural supply of

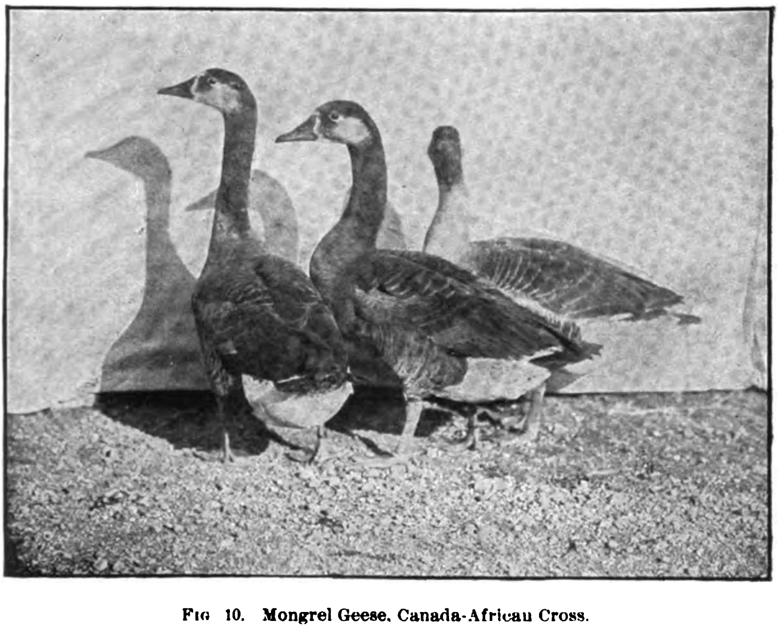

Fig 10. Mongrel Geese. Canada-African Cross.

water, as a spring-hole, small pond, or portion of a stream, if possible. Canada ganders have a very strong attachment for their mates, and will fight other ganders severely, especially during the breeding season. It is best, therefore, to have the different pairs sufficiently well separated so that their interests do not clash, as they are liable to injury in fighting. The eggs produced can be set under hens or other geese, so that as many eggs as possible may be obtained from the Canada gander and his mate.

Canada ganders are valuable as breeders for a much longer time than the ganders of domestic breeds. One instance was brought to our attention where a Canada gander forty-five years old was still serviceable, and in one season his progeny sold for the sum of seventy-five dollars.

Mongrel geese are almost never sold as green geese, being reserved for the Thanksgiving and Christmas trade. It is difficult to fatten them properly until the cool weather of fall, when they fatten readily, about the same course being pursued as in the fattening of other goslings. As a rule, they pick quite easily, and the flesh has a very handsome appearance, contrasted with the dark feathers. The feathers on the neck and wings are left, as in the dressing of green geese, and those upon the tail should also be left. If the wings are tied up with braid or tape, and the legs tied together underneath the tail, as the bird lies upon its back, the appearance is improved and the bird perhaps rendered more salable. Considerable skill is required, as well as patience and an abundance of natural facilities in the way of space and water supply, to successfully produce mongrels. The breeding stock is also an item of no inconsiderable amount, where large numbers are produced. It is a business which has to be gradually acquired and the details learned by experience in most cases.

PÂTÉ DE FOIE GRAS.

This is a luxury prepared from the livers of specially fattened geese. It is imported from Europe, where in certain sections of Germany and France, geese are fattened for the express purpose

of preparing the livers for sale to the manufacturers of this dainty. The manufacture of "goose-liver-pie," is mainly confined to the vicinity of Strasbourg.

The birds are closely confined in rather warm quarters and fed by "cramming" to the last stage of repletion, when the livers become enormously developed, and the birds, unless slaughtered when exactly the right stage has been reached, are subject to death from apoplexy. We do not know that the manufacture of *pâté de foie gras* has thus far been attempted in this country.

LEGS AND FEET.

The legs and feet, properly prepared and cooked, are considered good eating by some. In this country they are usually consigned to the butcher's scrap box. When used for eating they are first thoroughly washed and scalded until the outer skin can be easily removed, when they are slowly cooked in water, to which they give a gelatinous consistency. When done, they may be seasoned and eaten without further preparation, or they may be seasoned in a similar manner to that used in the preparation of pigs' feet, or the bones may be removed and the broth used for a soup stock.

PICKING LIVE GEESE.

In former times, live geese feathers commanded a much higher price than at present, and the feathers constituted no small part of the income derived from a flock of geese. A description of the custom followed by goose breeders in the early part of this century is interesting, as illustrating the value of the feathers at that time. One author[1] says, "that the first picking takes place about April 1st in England. The fine feathers of the breast and back are gently pulled. Care must be taken not to pull the down or pin-feathers. Quills may be pulled, five out of each wing, and they will bear pulling again in thirteen or fourteen weeks. The feathers can be pulled three times a year from the old geese and

[1] R. W. Dixon, M. D., London, 1805, quoted by Sir Wm. Jardine, Bart., in the Naturalist's Library, Vol. 14, pages 251-255.

ganders, about seven weeks intervening between each plucking. The young geese may be plucked once when thirteen or fourteen weeks old, but should not have the quills removed. Good feeding promotes the growth of feathers. Some pluck five times, as: Lady Day—March 25, Midsummer—June 24, Lammus—August 1, Michaelmas—September 29, and Martinmas—November 11. The feathers of a goose killed and plucked are worth sixpence, when plucked alive about threepence per head per annum is realized. 'Some wing them every quarter, taking ten feathers from each goose.' The quills sell at five shillings per thousand. In Wildmore Fen, geese return an income of one shilling per head for the featliers plucked from them."

The demand for feathers has so far decreased that, aside from those obtained when goslings are dressed for market, little, if any attention is paid to them. All growers are united in the opinion that goslings intended for market in the fall should by no means be picked alive, as in the first place the removal of the feathers is a serious interruption to the satisfactory growth and development of the gosling, and in the second place the goslings when dressed at a later date will not present a very satisfactory appearance for the market. If breeding geese are picked at about the time when the feathers are naturally shed, some feathers may be secured with little detriment to the geese. If, however, they are plucked alive every seven or eight weeks, between June and October, the demand upon the constitution of the bird for the growth of the repeated crops of feathers must be met by liberal feeding, or satisfactory results in the way of breeding will not be obtained.

In picking geese, a clean, close room is required, as the slightest motion of the bird is liable to scatter the feathers. A stocking or long bag is drawn over the head of the goose, and the wings must be held, care being taken not to injure them, as frequently results if they are locked together. Only the small feathers of the breast and sides should be removed, all the down should be left on the bird as well as the feathers along the back and the larger feathers on each side of the tail, which naturally hold the wings in place

and keep them from drooping. Care of course must be taken that the skin of the bird is not injured in removing the feathers. If a cold rain or storm comes immediately after the geese are plucked, they should be given shelter in a warm place. Liberal feeding promotes the rapid growth of feathers. Feathers should only be plucked when there is no blood whatever in the quills. Few, if any, goose-breeders at the present time pluck geese alive.

THE RAISING OF GEESE IN SWEDEN.

A correspondent[1] in Sweden in a communication to the writer under date of November 11th, 1897, gives the following information regarding the rearing of geese in that country, which is of interest in this connection as bearing upon the influence and benefit of cross breeding for market purposes.

The native Swedish goose is white, often mixed with a few dark feathers. There appear to be two varieties, one somewhat larger than the other. Our correspondent has found that the Swedish geese, crossed with the Toulouse, grow faster and become larger than pure breeds. As a rule, the Toulouse ganders are used with Swedish geese, as the geese are good sitters and excellent mothers. As the climate is cold, the geese are kept in winter in warm houses, but are let out every fine day for exercise. In March or April they begin laying in small sheds about three feet square and two or three feet high, which are placed in sheltered localities for the purpose. In these sheds nests are arranged, where later on the geese are set. Well dried Sphagnum moss, (such as nursery-men use for packing plants) is often used for the nests, and our correspondent states that insect enemies will never trouble geese where this moss is used for nests, and this fact is said to be true, also, when it is used for the nests of hens and turkeys. It is claimed that the moss does not offer the convenient hiding-place for lice which is afforded by the cavities in the stalks of straw.

Hens and incubators are sometimes used for hatching goose

[1] K. A. Högström.

eggs, but the geese themselves are generally relied upon for incubation. Nine eggs are usually placed under a goose; these are inspected on the tenth day, all infertile ones being removed. The goslings for the first week are fed on hard boiled eggs, and dough made from oatmeal mixed with milk, and chopped nettles or common grass. Later on only oatmeal dough mixed with milk is given, and when about two months old, they are only fed oats at night. The small sheds in which the geese sit are placed upon a lawn of short grass, when the goslings are two or three days old, and they are allowed to run with their mothers for an hour or two upon the grass, and when a week old they roam about at liberty the greater part of the day. They usually grow well, and few are lost. When two months old they are driven to larger pastures of grass and clover, where they have a supply of water, and from August to October they are pastured for several hours per day upon the mowing fields. Access to water every second hour at such times is found necessary. In the second week in October they are penned up for fattening, and are fed steeped oats and barley, powdered flaxseed cakes, cooked turnips and skimmed milk.

The eleventh of November is the common goose-eating day in Sweden, and the geese are marketed at this time. After being killed and picked, the body is rubbed with bran. They usually sell for from twelve to sixteen cents per pound. The early marketing and rather late spring combine to make a short season, and the weights reached are not usually large. The small Swedish geese average to weigh about nine pounds, dressed, the larger Swedish about ten pounds, and the Toulouse-Swedish cross, about eleven pounds dressed. Our correspondent gives the following figures as the result of his goose breeding for three years:

Year.	Total females more than one year old.	Total egg yield.	Average egg yield.	Average number of goslings hatched.	Total number of goslings reared.
1895	16	139	8.7	4.1	66
1896	15	201	13.4	4.9	74
1897	20	160	8.0	4.3	86

Our correspondent states that the small number of eggs produced interferes with the profit of the industry. This is perhaps in part due to the severe winter and short spring, which necessarily decreases the length of the laying season. Except in the matter of feeding, the management does not differ materially from that followed by our breeders.

EXPERIMENTS WITH GEESE.

INTRODUCTION.

Geese have been a portion of the poultry kept by the R. I. Experiment Station since the autumn of 1891, when specimens of Embden geese were imported from Germany. During 1892 a few Embden geese were raised, and in 1893 some experiments in cross breeding Embden and Toulouse geese were planned and carried out by Mr. Samuel Cushman, at that time in charge of the work of the Poultry Division. In 1894, the work was continued with the addition of African breeding stock, and three pairs of common geese from Prince Edwards Island. Eggs or young goslings were also secured from pure Toulouse, and pure Brown China matings, and pure Embden-African, Canada-African, and African-Toulouse cross matings. Goslings were hatched and reared on the grounds, and observations made in regard to growth and quality. In 1895 the breeding stock was considerably increased by the purchase of additional specimens, and White China geese were added to the breeds already kept. Plans were made to breed four kinds of geese pure, and to make fourteen different crosses. Some of the breeding stock did not arrive until late in the season, and some difficulty was experienced in getting the birds to mate satisfactorily. In addition, the sudden loss of the college dormitory by fire made it necessary to begin quarrying stone in the immediate vicinity of the goose yards and poultry houses. Those two factors were in part responsible for the very indifferent results secured that season.

An account of the goose experiments to the close of 1895, by

Mr. Cushman, is given in the Annual Report[1] for that year, with an outline of the plans for the work of 1896. The work of the Poultry Division continued under the direction of Mr. Cushman until his resignation, June 30th, 1896, when his duties were assigned to the writer of this report. Mr. James Lynch had charge of the feeding and care of the geese and goslings after about April 1st, 1896, until the close of the work hereafter reported. The experiments of 1897 were considerably disturbed by the removal of the Experiment Station poultry buildings and plant to a new location to the south of the old one, and farther away from the quarry. During the late winter and spring the quarry was again opened to obtain stone for the construction of Lippitt hall, and the necessary blasting disturbed the geese, interfered more or less with incubation, and flying stones from the blasts killed quite a number of goslings.

EXPERIMENTS WITH GEESE IN 1896.

Arrangements were made in December, 1895, to raise goslings from sixteen different crosses, and five pure breeds in 1896, and the matings were made up and the geese penned together some time before the laying season began. All the breeding stock used was of pure blood, and five different breeds were used, as follows: Embden, Toulouse, African, Brown China, and White China.

Pens were constructed of wire netting, two-inch mesh and four feet wide, in a naturally moist location across which two tiny brooks flowed during the winter and early spring. The pens averaged about 60x60 feet in size, and in each one a basin, some eighteen inches deep and eight feet in diameter, was dug, which filled with water from the brooks and soil until the weather became dry. The earth from these basins was thrown up into a mound for the benefit of the geese during freshets or exceptionally wet weather. When the natural supply of water failed, an iron

[1] Annual Report R. I. Expt. Sta., 1895, pages 327-358.

pipe was laid on the surface from the six-inch main which carries the college water supply to the stand-pipe. Large oil barrels were purchased, cut in two in the middle, each making two tubs, which were sunk into the ground, one in each yard, until the top was about level with the surface. Stop cocks were provided at intervals along the line of pipe, and by the use of 150 feet of hose the tubs could all be filled with water as often as necessary—usually every day. For nests, large barrels were provided and kept supplied with straw. Those used were rejected oil barrels with iron hoops, and when well painted they are serviceable for several years. A cracked head, chine or stave makes them useless for holding oil, and they can be purchased from the dealer in barrels at a reasonable price. The nest barrels were painted red, and on each one was stenciled in white figures about four inches high the number of the pen, and the attendant was instructed to mark with a pencil the number of the pen upon the eggs as removed from the barrels, in order to insure accuracy. Some of the yards were provided with board coops originally constructed for chickens, which could be utilized for shelter, but which were rarely used by the geese even in storms. A bunch of straw or litter was occasionally thrown into the yards for bedding. Two matings had the freedom of a pasture adjoining the goose yards, to see what influence, if any, it would have upon the number and fertility of the eggs produced.

MATING BREEDING STOCK.

Whenever geese were purchased each one was marked on arrival by a numbered metal band around one leg, and a record made of the number. As metal bands frequently become loosened and lost, each bird was also marked by punching one or more holes in the web of the feet, and a record was made of such foot marks in connection with the band number.

The matings for the season of 1896 were as follows:

Yard No.	1	Toulouse	gander and	2	African	geese.
" "	2	Embden	" "	2	Brown China	"
" "	3	Embden	" "	2	Toulouse	"
" "	4	African	" "	2	Toulouse	"
" "	5	Brown China	" "	2	African	"
" "	6	Brown China	" "	1	Brown China	goose.
" "	7	Toulouse	" "	2	Embden	geese.
" "	8	African	" "	2	Embden	"
" "	9	Brown China	" "	4	Embden	"
" "	10	Embden	" "	2	White China	"
" "	11	Toulouse	" "	2	Brown China	"
" "	12	African	" "	2	Brown China	"
" "	13	White China	" "	1	Embden	goose.
" "	14	Brown China	" "	2	Toulouse	geese.
" "	15	Embden	" "	2	African	"
" "	16	White China	" "	2	White China	"
" "	17	African	" "	2	African	"
" "	19	Embden	" "	2	Embden	"
" "	20	Toulouse	" "	1	White China	goose.
" "	21	White China	" "	2	Toulouse	geese.
" "	22	White China	" "	2	Embden	geese.
" "	"	White China	" "	1	Toulouse	goose.

Pen No. 18 was intended for a pure Toulouse mating, but as the birds selected never mated, the pen is omitted from this and following tables.

FEEDING.

Twice a week during the laying season the geese were fed a cooked mash made by mixing about two parts Indian corn meal, two parts wheat bran, two parts wheat middlings, and one part beef scraps by measure with boiling water. At other times they were fed whole grain—usually about two-thirds oats and one-third wheat. They were fed what they would readily eat up clean twice daily, morning and afternoon. Oyster shells, cracked rather coarsely, were kept in the pens at all times. Waste cabbage, consisting of outer leaves, trimmings and loose heads, were pur-

chased and fed in small quantities several times a week. A little salt and charcoal were frequently used in the cooked food.

EGG RECORDS.

The nest barrels were kept well supplied with straw, and a strip of board three or four inches wide, fastened across the open end at the ground, kept it from being pulled out. As soon as the geese began laying care was exercised to collect the eggs frequently, so that none should be chilled. The number of the pen as recorded on the barrel was immediately written in pencil upon the egg, and later the number was stamped on with a stencil, and the date was added. The eggs were kept in trays, in a moderate, uniform temperature, and turned daily until wanted for incubation.

TABLE I.—*Record of Goose Eggs Laid in 1896.*

Yard. No.	Mating. Male.	Mating. Female.	No. of Females.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.	Average.
7	Toulouse,	Embden.....	2	...	...	12	10	...	...	22	11
8	African,	Embden. ..	2	...	2	12	7	8	...	29	14.5
9	Brown China,	Embden.....	4	...	...	31	31	32	..	94	23.5
13	White China,	Embden.....	1	...	...	8	8	1	...	17	17
19	Embden,	Embden.....	2	..	3	16	10	11	6	46	23
	Totals...............		11	...	5	79	66	52	6	208	18.9+
1	Toulouse,	African	2	...	...	16	12	2	...	30	15
5	Brown China,	African	2	...	3	18	13	10	...	44	22
15	Embden,	African.....	2	...	...	18	8	5	...	31	15.5
17	African,	African... .	3	...	...	18	13	11	...	42	14
	Totals.............		9	...	3	70	46	28	...	147	16.3+
3	Embden,	Toulouse ...	2	...	...	26	23	14	...	63	31.5
4	African,	Toulouse	2	...	..	22	11	8	...	41	20.5
14	Brown China,	Toulouse	2	...	...	23	30	26	1	80	40
21	White China,	Toulouse	2	...	...	9	23	9	...	41	20.5
	Totals......		8	...	...	80	87	57	1	225	28.1+
2	Embden,	Brown China.	2	...	5	11	16	15	...	47	23 5
6	Brown China,	Brown China.	1	...	2	8	8	3	...	21	21
11	Toulouse,	Brown China.	2	...	3	15	23	23	7	71	35.5
12	African,	Brown China.	2	...	...	26	29	23	7	85	42.5
	Totals.......		7	..	10	60	76	64	14	224	32.0[1]
10	Embden,	White China.	2	2	2	9	11	9	2	35	17 5
16	White China,	White China.	2	...	...	15	20	27	11	73	36.5
20	Toulouse,	White China.	1	...	3	13	13	15	6	50	50
	Totals........... ...		5	2	5	37	44	51	19	158	31.6[1]
22*	White China,	Toulouse ..	1	...	...	12	30	10	...	52	17.3+
	White China,	Embden. ...	2								

* As females of two breeds were in this pen the eggs laid are not included in the general averages.

[1] On page 357 of the Annual Report for 1896 these averages are given as 31.00 each. A careful revision of the figures has changed them as above. The number of eggs laid by the White China goose in pen 20 here includes 8 eggs laid in February which were omitted at that time.

Two eggs were laid in January by a White China Goose in yard No. 10, one on the 11th and one the 13th of the month, and only two eggs were laid in this yard in February. Such spasmodic laying is of little value when done so early in the season. In all, 23 eggs were laid in February, probably by eight different geese. The largest number from any one pen was five, from a Brown China goose in pen No. 2. Of the 25 eggs laid before March 1st, 17 were from Brown or White Chinas, 3 from Africans, and 5 from Embdens. None of the Toulouse geese had laid. Early in March laying became quite general, and by the end of the month 338 eggs had been laid by 43 females, an average of a little over 7.8 eggs each. The Toulouse had the highest average—just 10 eggs each; Brown Chinas next with 8.57+ eggs each; then Africans, with an average of 7.77+; White Chinas, 7.4; and last, Embdens, with an average of 7.18+ eggs each. In April a few more eggs were laid than during March, the total being 349, and the average a little more than 8.1 eggs each. The Toulouse geese lacked but one egg of averaging 11 eggs each; the Brown and White Chinas also laid more eggs this month than in March, but the Embdens averaged but 6 eggs each, and the Africans only 5.1+ eggs. In May the total egg production was only 262 eggs, an average of a little over 6 eggs each. This month the White Chinas made the highest average, just a little over 10 eggs each, and the Brown Chinas a trifle more than 9 eggs each. The Toulouse average was reduced to 7.1+, the Embden average to 4.7+, and the African average to 3.1+ eggs each. In June only 40 eggs were laid by the 43 females. The Africans laid no eggs, the Toulouse only 1 egg, the Embdens 6 eggs, the Brown Chinas 14 eggs—an average of 2 eggs each—and the White Chinas again took the lead for egg production by laying 19 eggs—lacking only one of averaging 4 eggs each. The total number of eggs laid during the season was 1,014, an average of 23.58+ each. In the last two columns of table I are given the total number of eggs obtained from each yard, and the average number from each goose. In the table the females of the different breeds are

grouped together and the average obtained from each breed. Brown China stands at the head for egg production, with an average of 32, and White Chinas rank second, and but very little lower, their average being 31.6 eggs each. Toulouse occupy the third place, with an average of 28.1+; Embdens averaged 18.9+, and Africans 16.3+ eggs each. The geese from whose records these figures for egg production were calculated were all subject to practically like conditions as to quality of food, water, liberty, etc. The egg yields are rather low for any of the breeds, the Africans particularly falling far short of the records made in some instances.[1] The largest individual record was 50 eggs, laid by a White China goose in pen No. 20. The great difference in individuals is readily seen by comparing the records of the White China geese in pen No. 10 with that of pen No. 20—17.5 eggs in one instance, and 50 eggs in the other. Almost as great differences are to be found in the egg production of the different females in each breed. The highest Brown China average was 42.5, and the lowest 21 eggs. The best Toulouse average 40, and the poorest 20.5, made by two pens. The best Embden average was 23.5 eggs, and the poorest only 11 eggs.

The largest African average was 22 eggs, and the lowest 14. It is worth noting that the three females (two Embden and one Toulouse) in pen 22, where they had the liberty of a large pasture only averaged 17.3+ eggs each, or less than the average of either the Toulouse or Embden females in all the pens.

WEIGHT OF EGGS.

In order to obtain some data as to the relative size of the eggs laid by the different breeds of geese, the weights of a large number were taken, and we give a summary of the same, with calculated average weights in the following table:

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[1] See page 486.

TABLE II.—*Record of Weights of Eggs Laid by Geese in 1896.*

Yard. No.	Mating. Males.	Mating. Females.	No. of Females.	Total No. of eggs weighed.	Total weight, ounces.	Average weight, ounces.	
7	Toulouse,	Embden . . .	2	21	121	5.761	Average weight of 194 Embden eggs, 6.556 ounces.
8	African,	Embden	2	26	159	6.115	
9	Brown China,	Embden	4	89	587	6.595	
13	White China,	Embden	1	17	109	6.411	
19	Embden,	Embden . . .	2	41	296	7.219	
			11	194	1,272		
1	Toulouse,	African......	2	30	180	6.	Average weight of 136 African eggs, 6.654 ounces.
5	Brown China,	African......	2	38	256	6.736	
15	Embden,	African......	2	28	192	6.500	
17	African,	African......	3	40	277	6.925	
			9	136	905		
3	Embden,	Toulouse	2	59	341	5.779	Average weight of 210 Toulouse eggs, 6 257 ounces.
4	African,	Toulouse . .	2	40	260	6.500	
14	Brown China,	Toulouse ...	2	78	507	6.500	
21	White China,	Toulouse	2	33	206	6 242	
			8	210	1,314		
2	Embden,	Brown China.	2	42	226	5.380	Average weight of 201 Brown China eggs, 5.450
6	Brown China,	Brown China.	1	19	91	4.789	
11	Toulouse,	Brown China.	2	61	331.5	5.434	
12	African,	Brown China.	2	79	447	5 658	
			7	201	1095.5		
10	Embden,	White China.	2	28	142	5.071	Average weight of 121 White China eggs. 5.545 ounces.
16	White China,	White China.	2	51	300	5.882	
20	Toulouse,	White China.	1	42	229	5.452	
			5	121	671		

This table contains the weights of 862 eggs laid by 40 geese of five different breeds. The average weight of all the eggs weighed was 6.099+ ounces. That is nearly three times the weight of a hen's egg, as the average weight of 94 eggs from Rhode Island Red hens was 2.127+ ounces. The largest one weighed 2.550+ ounces, and the smallest one 1.640+ ounces. The eggs were all selected for setting and were of good size. The largest, from a setting of Plymouth Rock eggs, weighed 2.645+ ounces. The Embden females in yard No. 19 laid eggs of the largest average weight, viz.: 7.219 ounces. No other geese laid eggs averaging 7 ounces or over in weight.

The smallest eggs were laid by a typical Brown China goose in pen No. 6, the average weight being only 4.789 ounces. The eggs laid by the Africans were most uniform in size and shape and had the greatest average weight.

136	eggs	laid by	9 African	geese,	averaged	6.654+	ounces	in	weight.
194	"	"	11 Embden	"	"	6.556+	"	"	"
210	"	"	8 Toulouse	"	"	6.257+	"	"	"
121	"	"	5 White China	"	"	5.545+	"	"	"
201	"	"	7 Brown China	"	"	5.450+	"	"	"

Eggs laid by the Embdens were next in average weight to those laid by the Africans, and the Toulouse geese laid eggs a little lighter in average weight than the Embdens, and, therefore, rank third in respect to the size of eggs. Brown China geese eggs averaged a little less in weight than those from White Chinas. The average weight of eggs from both the Brown and White Chinas together was practically an *ounce less* than the average weight of the eggs laid by the African, Embden, and Toulouse breeds.

INCUBATION AND HATCHING.

When a sufficient number of eggs from most of the yards had been obtained to make a setting for one or more hens, incubation began. Broody hens were purchased and provided with nests in

boxes to which they could be confined, and from which they were released daily to get food and water and occasionally a dust bath. Five goose eggs were given to each, care being taken to keep those of the same yard number together so far as possible. Within ten days after setting the hens the eggs were tested in the ordinary way, by holding them before a bright light, all infertile ones removed, and the fertile eggs concentrated under a less number of hens. Only eggs of one number were allowed under a single hen, that there might not be any difficulty in identifying the goslings hatched, and marking them to correspond with the pen number on the eggs. In order that as many different kinds of eggs might be set at one time as possible, so as to have the goslings of the same age, for the purpose of comparing the growth, some eggs were kept longer than they should have been before setting them. It was orignally planned to set the eggs every ten days, but some difficulty in securing enough broody hens at the proper time caused a longer period to elapse between the setting in most instances. Table III gives the various dates on which eggs were set, with the number from each pen, the number tested out and the number of goslings hatched.

TABLE III.

Showing the Number of Eggs Set at Different Times, the Number Tested Out, and Goslings Hatched, 1896.

Yard No.		1st Hatch, April 25.			2d Hatch, May 7.			3d Hatch, May 23.			4th Hatch, June 4.			5th Hatch, June 17.			6th Hatch, July 2.		
		No. of eggs set, March 27.	No. tested out.	No. of goslings hatched.	No. of eggs set, April 7.	No. tested out.	No. of goslings hatched.	No. of eggs set, April 28.	No. tested out.	No. of goslings hatched.	No. of eggs set, May 5.	No. tested out.	No. of goslings hatched.	No. of eggs set, May 18.	No. tested out.	No. of goslings hatched.	No. of eggs set, June 2.	No. tested out.	No. of goslings hatched.
1.	Toulouse-African	13	8	5	6	......	4	4	3	1	7	2	4	......	......	......	......	......	......
2.	Embden-Brown China	11	9	1	6	4	2	7	8	2	7	3	4	7	1	5	8	......	......
3.	Embden-Toulouse	19	9	8	8	4	1	14	5	6	1	......	1	10	......	9	2	......	......
4.	African-Toulouse	18	10	8	9	2	5	2	1	......	7	2	5	3	......	8	......	......	......
5.	Brown China-African	21	7	4	2	1	1	8	5	1	......	......	......	5	......	3	4	1	1
6.	Brown China Pure	8	3	1	2	1	......	5	4	1	8	......	2	1	......	......	......	......	......
7.	Toulouse-Embden	7	6	1	7	2	3	3	8	......	3	3	......	......	......	......	......	......	......
8.	African-Embden	13	5	5	1	......	......	6	3	3	......	......	......	8	......	7	......	......	......
9.	Brown China-Embden	21	12	6	19	5	5	16	10	3	7	2	1	14	9	3	18	2	1
10.	Embden-White China	7	7	......	5	5	......	5	1	1	4	3	1	3	3	......	4	3	......
11.	Toulouse-Brown China	16	5	6	5	2	1	16	6	7	5	......	3	12	5	4	8	6	2
12.	African-Brown China	22	4	12	11	1	9	15	6	7	11	2	8	12	1	6	9	......	1
13.	White China-Embden	5	4	......	4	......	4	3	1	1	5	1	4	......	......	......	......	......	......
14.	Brown China-Toulouse	18	11	3	18	2	9	14	2	10	10	......	4	12	3	6	12[1]	6	6
15.	Embden-African	12	1	9	7	1	4	3	1	2	4	......	4	2	......	2	......	......	......
16.	White China Pure	10	8	1	9	8	......	11	11	......	8	8	......	13	10	1	11	10	......
17.	African Pure	15	8	7	3	......	3	9	3	6	7	1	4	3	......	......	4	2	1
19.	Embden Pure	15	13	......	6	......	2	7	7	......	5	3	......	4	3	......	7	4	......
20.	Toulouse-White China	12	10	......	7	6	......	7	7	......	4	4	......	7	6	......	6	5	1
21.	White China-Toulouse	......	......	......	11	9	......	12	9	3	2	2	......	6	6	......	3	2	......
22.	White China - { Toulouse / Embden }	5	5	......	19	13	2	6	5	......	10	5	3	8	4	......	......	......	......
	Totals	269	145	72	160	66	55	173	96	54	110	41	48	130	51	49	56	41	13
	No. of goslings weighed at 5 weeks old			66			49			50			48			49			12
	No. of goslings weighed at 8 weeks old			65			11[2]			49			47			49			12
	No. of goslings weighed at 10 weeks old			52[2]			......			49			47			49			12

[1] Eleven eggs set under a turkey—six goslings were hatched.
[2] On the nights of June 22d and June 29th dogs broke into the pens, and over sixty goslings and geese were killed or maimed.

A total of 291 goslings was hatched, and when weighed, at 5 weeks old, there were 281 recorded, showing a loss of only 10 from the number during that time. Every one of the 5th hatch and all but one each from the 4th and 6th hatches were raised to maturity. None were lost after the fifth week, excepting those killed and injured by dogs.

In table IV we have grouped together the data relating to the egg yields, the number set, tested out and hatched, from the representatives of each breed, classing the males and females separately. The percentage of eggs tested out as infertile from those set has been calculated for each yard, and the percentage of goslings hatched from the total number of eggs set.

TABLE IV.—*Showing the Relative Fertility of Eggs Produced by Different Matings of Geese in 1896.*

Yard No.	Matings.	Total No. of Eggs. Laid.	Set.	Tested out.	Per cent. of eggs tested out from eggs set.	Total No. of goslings hatched.	Per cent. of goslings from eggs set.
	Embden Females.						
7	Toulouse- Embden	22	20	14	70 00	4	20.00
8	African- "	29	28	8	25.00	15	53.57
9	Brown China- "	94	90	40	44.45	19	21.11
13	White China- "	17	17	6	35.29	9	52.93
19	Embden- "	46	44	30	68.18	2	4.54
		208	199	98	49.24	49	24.62
	Embden Males.						
2	Embden-Brown China.....	47	41	20	48.78	14	34.14
3	" Toulouse	63	54	18	33.33	20	37.03
10	" White China. ..	35	28	22	78.57	2	7.14
15	" African...	31	28	6	21.42	21	75.00
19	" Embden.........	46	44	30	68.18	2	4.54
		222	195	96	49.23	59	30.25
	African Females.						
1	Toulouse- African. ...	30	30	13	43.33	14	46.66
5	Brown China- "	44	40	14	35.00	10	25.00
15	Embden- " ...	31	28	6	21.42	21	75.00
17	African- "	42	41	15	36.58	21	51.21
		147	139	48	34.53	66	47.48
	African Males.						
4	African-Toulouse.	41	39	15	38 46	21	53.84
8	" Embden..	29	28	8	25.00	15	53.57
12	" Brown China.....	85	76	14	18.42	43	56.59
17	" African	42	41	15	36.58	21	51.21
		197	184	52	28.26	100	54.34

TABLE IV.—*Continued.*

Yard No.	Mating.	Total No. of Eggs. Laid.	Set.	Tested out.	Per cent. of eggs tested out from eggs set.	Total No. of goslings hatched.	Per cent. of goslings from eggs set.
	Toulouse Females.						
3	Embden– Toulouse....	63	54	18	33.33	20	37.03
4	African– "	41	39	15	38.46	21	53.84
14	Brown China– "	80	79	24	30.38	38	48.10
21	White China– "	41	34	28	82.35	3	8.82
		225	206	85	41.26	82	39.80
	Toulouse Males.						
1	Toulouse–African........	30	30	13	43.33	14	46.66
7	" Embden........	22	20	14	70.00	4	20.00
11	" Brown China....	71	62	24	38.70	23	37.09
20	" White China ...	50	43	38	88.37	1	2.32
		173	155	89	57.41	42	27.09
	Brown China Females.						
2	Embden– Brown China.	47	41	20	48.78	14	34.14
6	Brown China– " "	21	19	8	42.10	4	21.05
11	Toulouse– " "	71	62	24	38.70	23	37.09
12	African– " "	85	76	14	18.42	43	56.59
		224	198	66	33.33	84	42.42
	Brown China Males.						
5	Brown China–African.....	44	40	14	35.00	10	25.00
6	" " Brown China.	21	19	8	42.10	4	21.05
9	" " Embden.. ..	94	90	40	44.45	19	21.11
14	" " Toulouse ...	80	79	24	30.38	38	48.10
		239	228	86	37.71	71	31.14
	White China Females.						
10	Embden– White China..	35	28	23	78.57	2	7.14
16	White China– " " ..	78	62	55	80.70	2	3.22
20	Toulouse " " ..	50	43	38	88.37	1	2.32
		158	133	115	86.45	5	3.75

TABLE IV.—*Continued.*

Yard No.	Mating.	Total No. of Eggs. Laid.	Set.	Tested out.	Per cent. of eggs tested out from eggs set.	Total No. of goslings hatched.	Per cent. of goslings from eggs set.
	White China Males.						
13	White China–Embden. ...	17	17	6	35.29	9	52.93
16	" " White China.	73	62	55	80.70	2	3.22
21	" " Toulouse ...	41	34	28	82.35	3	8.82
22	" " { Embden... Toulouse.. }	52	48	32	66.66	5	10.41
		183	161	121	75.15	19	11.80

The highest per cent. of goslings from eggs set was from yard 15, in which an Embden gander was mated with African geese. Just 75 per cent. of the eggs set produced goslings. The next best hatch, 56.59 per cent., was from yard 12; African gander and Brown China geese. An African gander mated with females of his own breed or Toulouse, Embden or Brown China breeds, produced goslings from more than 50 per cent. of the eggs set (yards 17, 4, 8 and 12), while of the opposite matings, yard 15, already mentioned, was best of all. Yard 1, Toulouse gander and African geese, produced 46.66 per cent. of goslings, and Brown China gander with African geese, yard 5, gave only 25 per cent. as many goslings as eggs set. In the matings mentioned the White China breed has not appeared, and by reference to the two last classes of the table it will be seen that, with one exception, all the White China matings made a very low record of fertile eggs. The exception was yard 13, in which was a White China gander and one Embden goose. From this yard goslings were hatched to the extent of 52.93 per cent. of the number of eggs set. The next highest per cent. of goslings hatched from a yard where either White China males or females were used was 10.41 per cent. in the case of yard 22, and the lowest record from any yard

was 2.32 per cent. from number 20, where a Toulouse gander was mated with a White China goose. The indifferent results obtained with all but one of the White China matings are illustrative of the general opinion which goose raisers have of this breed, one of whom said, "Beware of the white geese with a yellow knob."

Under natural conditions, geese, like other water-fowl, copulate while in water, and when Canada geese are kept for the production of mongrels, water for swimming purposes is considered necessary, in order that fertile eggs may be produced. It is quite possible that some breeds of geese may require access to larger water privileges than others, and that individuals which prove poor breeders in yards, supplied only with a tub of water, may, with full liberty and access to a pond or stream, be satisfactory in that respect. In table V we have summarized the figures representing the eggs tested out, and the goslings hatched, as compared with the number of eggs set for the females and males of each breed, and calculated the average per cents.

TABLE V.—*Showing Average Per Cents. of Eggs Tested Out and Goslings Hatched from Eggs Set in 1896.*

BREED.	SEX.	Per cent. of eggs tested out from eggs set.	Average.	Per cent. of goslings hatched from eggs set.	Average.
African	Females	34.53	31.39	47.48	50.91
	Males	28.26		54.34	
Brown China	Females	33.33	35.52	42.42	36.78
	Males	37.71		31.14	
Toulouse	Females	41.26	49.33	39.80	33.44
	Males	57.41		27.09	
Embden	Females	49.24	49.23	24.62	27.43
	Males	49.23		30.25	
White China	Females	86.45	80.80	3.75	7.77
	Males	75.15		11.80	

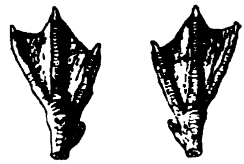
Africans gave the largest per cent. of fertile eggs for both males and females, and, of course, the highest average, 50.91 per cent. The other breeds ranked in the following order: Brown China, Toulouse, Embden and White China, the last having only 7.775 per cent. of fertile eggs. It is but fair to call attention to the fact that the Toulouse and Embden averages were cut down by the White China matings in each case, and in the case of the Embdens by the low percentage of the pure bred mating—yard No. 19. No White Chinas were mated with Africans or Brown Chinas in 1896, and their percentages did not therefore suffer in the same proportion as in the case of the Toulouse and Embden breeds. Omitting the White China mating, yard No. 21, from the calculation and the Toulouse average per cent. of goslings to eggs set would have been 41.175 instead of 33.445, and would have given it a rank above Brown China. Embden *geese* gave the best results when mated with an African gander (yard 8), while Embden *ganders* gave good satisfaction mated with either African, Toulouse or Brown China geese.

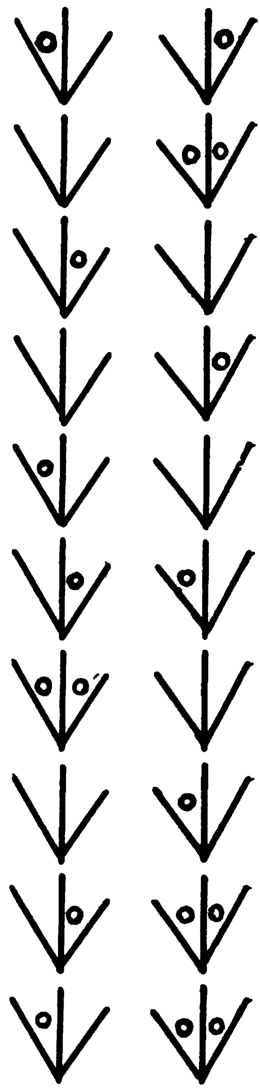
MARKING THE GOSLINGS.

As each egg had upon the shell the stencilled number of the mating by which it was produced, and as each sitting hen had eggs of only one number under her at hatching time, there was no difficulty in determining the parentage of the goslings so long as they remained with the hen in the nest. But as they were to be taken from the hens and raised in artificial brooders, it became necessary to mark each gosling in some permanent manner so that at any time the progeny of any one yard could be identified and separated from those of other yards. This was done by punching a hole in the web of the foot—the position of the hole or holes serving to distinguish the various matings, one from the others. Goslings a few weeks old, and geese, are always handled by grasping the hand about the neck of the bird just below the head, and as it is raised from the ground it is turned

around so that its back is toward the person holding it. In this position it cannot scratch or strike with the wings; and the right foot of the bird is, of course, on the right hand side, and the feet can be easily examined for the marks. If the holes close up by growth, the web will be thicker at the point where a hole was punched, and the skin will be smooth and usually lighter colored. The following is the arrangement of marks used. A sharp leather punch, with a piece of thick leather to place under the web while cutting the holes, was used in marking.

The goslings produced by the different matings were marked as follows, in 1896:





Yard No. 1. Toulouse......African............

Yard No. 2. Embden.... ..Brown China. ....

Yard No. 3. Embden.......Toulouse...........

Yard No. 4. African.......Toulouse...........

Yard No. 5. Brown China. African.... .....

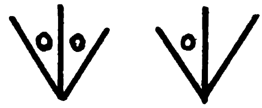
Yard No. 6. Brown China..Brown China.......

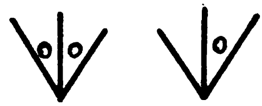
Yard No. 7. Toulouse......Embden............

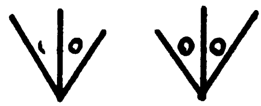
Yard No. 8. African..... .Embden............

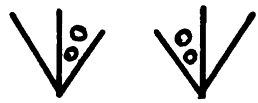
Yard No. 9. Brown China..Embden....... ....

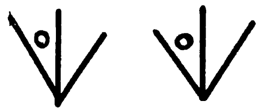
Yard No. 10. Embden. .....White China........

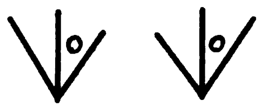
Yard No. 11. Toulouse......Brown China....


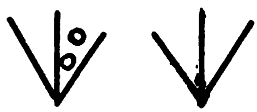
Yard No. 12. African.......Brown China.....


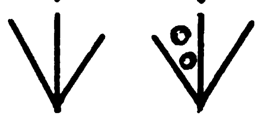
Yard No. 13. White China..Embden ....


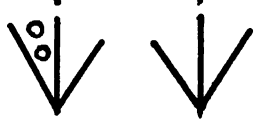
Yard No. 14. Brown China..Toulouse.... ...


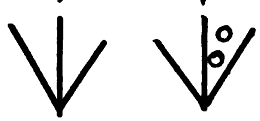
Yard No. 15. Embden. .... African...... . ...


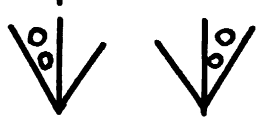
Yard No. 16. White China..White China......


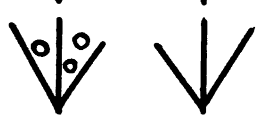
Yard No. 17. African. ......African..........


Yard No. 18. Toulouse......Toulouse.........


Yard No. 19. Embden.......Embden...... ...


Yard No. 20. Toulouse .....White China .....


Yard No. 21. White China..Toulouse.........


Yard No. 22. White China $\left\{\begin{matrix}\text{Toulouse}\\ \text{Embden}\end{matrix}\right\}$... .....


In order to distinguish the different hatches one from another, so that when grown the age of any gosling could be determined, one claw or toe nail was clipped off with a sharp knife when the gosling was small, a different claw being cut for the different hatches. The *first* hatch had the *middle* claw of the *left* foot clipped; the *second* hatch, the *middle* claw of the *right* foot; the *third* hatch, the *outside* claw of the *right* foot; the *fourth* hatch, the *outside* claw of the *left* foot; the *fifth* hatch, the *inside* claw of the *right* foot; and the *sixth* hatch, the *inside* claw of the *left* foot. By clipping more than one claw, many other marks may be arranged to serve in identifying birds belonging to different owners, or to assist in the identification of stolen fowls. It might be undesirable to clip the claws from young pure bred birds designed for breeding or show purposes, but it does no harm whatever in the case of market goslings.

CARE OF THE GOSLINGS.

When hatched, the goslings were taken from the hens and placed in a "Peep o' Day" brooder located out of doors where the grass was short and tender. The temperature was regulated to suit their needs and governed considerably by the weather; if very sunny and warm, less heat in the brooder was required, and on cold days, more was needed to keep them comfortable. From 95 to 90° F. during the first few days, the temperature was gradually allowed to fall to 75° or 60°, as the goslings increased in size and age. The very earliest hatches may require a brooder for three weeks or more, but goslings hatched in June will hardly require artificial heat after they are 10 days old. The first hatch was put into the brooder April 26th, and when it was wanted for the third hatch the oldest ones were quite able to do without it. Two brooders were used. Wire poultry netting, one foot wide, held by small iron stakes with a double point made for the purpose, was used to enclose a small area around the brooder as a pasture for the young goslings. As soon as the grass was eaten

Fig. 11. Goslings hurdled by wire fencing two feet high, in a field of Dwarf Essex Rape.

off by the goslings, additional space was given by moving the fence. When they were large enough to leave the brooder, they were hurdled in young oats two or three inches high by the use of wire poultry netting, two feet wide, held by stakes of iron with double points as in the case of the other netting. A box or portable coop was placed inside the fence, facing the north, to provide them shelter from the sun during the middle of the day, and cover during rains. Every night they were driven into pens in the large brooder house, or into yards for better protection.

They were fed at first, while in the brooder, four times daily, with finely cracked white flint corn, scalded and mixed with a little sweet meal. Water was given them for drinking. A drinking fountain, or shallow pan filled with small stones was used to prevent their getting into the water and getting the fine down with which they are covered wet. A shallow pan filled with sharp sand saturated with water, was kept in the pen all the time. After they were ten days old, a little fresh green oats, a few inches high, or other green food, was put into their pen at night, and they were also given a feed of dough made from scalded cracked corn and meal seasoned with a very little salt, when they were sent in for the night.

FODDER CROPS FOR GEESE.

In the last annual report[1] is given a brief account of the green crops provided for furnishing food for goslings and geese in lieu of pasturing them upon grass, the supply of which was limited. Rye was sown in the fall of 1895, and oats and oats and pease were sown in the spring, as soon as the soil could be prepared. Of these the young goslings prefer the oats, but will eat the pease when the oats are all consumed. They will feed upon the rye when it is young and tender, but leave it at any time for oats. Turnip, beet, rape, and cabbage seeds may all be sown very early, and as green food all are eagerly eaten by goslings. Dwarf Essex

[1] Ninth Annual Report R. I. Agl. Expt. Sta., 1896, pages 359-362.

rape was sown broadcast on June 13th, and on July 19th it had made a thick growth six or eight inches high, and the goslings were hurdled upon it by fencing off small sections at a time. When they had eaten off all the leaves they were changed to a fresh location, and new leaves soon began to start from the stems of the rape, and a second and larger growth was ready for feeding August 17th, when goslings were again hurdled on the field. This plant is much used in England for feeding sheep. Moderate frosts do not injure it. The seed is inexpensive, costing only about fifteen cents per pound, and five pounds will sow an acre in drills twenty inches apart. Twice as much may be sown broadcast, but on rich land less will be sufficient. The plant resembles kale in appearance and manner of growth, and the seed is about the size of turnip seed. It may be sown like turnip seed, and covered with a roller or brush harrow. Sorghum was relished by the goslings, and sweet corn is a standard green food. Early orange sugar cane and early amber cane were two varieties of sorghum used. The ground must be warm and mellow when the seeds are sown, as they are tender plants, but grow rapidly in summer weather. Neither corn nor sorghum, after being killed by frost, is suitable for feeding geese. Barley will withstand some frost, and makes a good green food.

LIVE WEIGHTS.

The goslings were weighed at about five weeks, eight weeks and ten weeks old, and as all the goslings had the same opportunity for growth, the capacity of the goslings from the various matings for rapid growth and early maturity can be readily compared. On the night of June 22d dogs broke through the wire fence into the pen where the second hatch birds were confined, and drove them out and chased them across the fields and a portion of the experiment plots, and killed or maimed a large portion of them. June 29th the geese in the field adjoining the yards were killed or maimed, and a few goslings also. In the two nights, 54 gos-

lings, 5 geese and three ganders were killed or maimed, and although, under the "dog law," the Station received a fair market value for them, the loss to the experiment could not be replaced. The 4th, 5th, and 6th hatches were weighed at about 150 days old, as well as at the three earlier dates. At that age they were in good, thrifty condition, but not fat. The following tables give the weights of the birds at different times, the average weights, and the gains made between the different weighings.

TABLE VI.—*Showing Weights of Goslings Hatched April 25th, 1896.—First Hatch.*[1]

Yard.	Mating.	Weight May 30, 35 Days Old. No. of goslings.	Total pounds.	Average pounds.	Weight June 20, 56 Days Old. No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	Weight July 4, 70 Days Old. No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
1	Toulouse–African	3	7.13	2.38	3	18.53	6.18	3.75	3	28.13	9.38	3.25
2	Embden–Brown China	1	1.56	1.56	1	6.44	6.44	4.88	1	9.56	9.56	3.12
3	Embden–Toulouse	1	1.50	1.50	1	5.00	5.00	3.50	1	6.38	6.38	1.38
4	African–Toulouse	9	21.00	2.33	9	58.45	6.49	4.16	7	62.38	8.91	2.42
5	Brown China–African	2	4.75	2.38	2	12.50	6.25	3.87	1	7.56	7.56	1.31
6	Brown China Pure	1	1.31	1.31	1	4.25	4.25	2.94	.....	.....	.....	.....
7	Toulouse–Embden	2	3.38	1.69	1	5.75	5.75	4.06	.....	.....	.....	.....
8	African–Embden	6	13.38	2.23	6	38.75	6.46	4.23	4	33.75	8.44	1.98
9	Brown China–Embden	5	11.38	2.69	5	29.19	5.84	3.15	4	32.56	8.14	2.30
11	Toulouse–Brown China	5	11.44	2.71	5	30.50	6.10	3.39	5	38.19	7.63	1.53
12	African–Brown China	11	25.38	2.31	11	66.25	6.02	3.71	10	78.00	7.80	1.78
14	Brown China–Toulouse	2	5.56	2.78	2	14.13	7.06	4.28	2	16.41	8.20	1.14
15	Embden–African	11	29.88	2.72	11	66.92	6.08	3.36	9	88.50	9.83	3.75
16	White China Pure	1	1.88	1.88	1	5.00	5.00	3.12	.....	.....	.....	.....
17	African Pure	6	14.00	2.33	6	36.50	6.08	3.75	5	44.50	8.90	2.82

[1] Suffered loss from attack by dogs June 22d and 29th.

TABLE VII.—*Showing Weights of Goslings Hatched May 7th, 1896.—Second Hatch.*[1]

Yard.	Mating.	Weight June 15, 39 Days Old.			Weight July 4, 60 Days Old.			
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
1	Toulouse-African	4	18.56	4.64	1	9.38	9.38	4.74
2	Embden-Brown China	2	7.69	3.85	......	......	......	......
3	Embden-Toulouse	1	4.44	4.44	......	......	......	......
4	African-Toulouse	5	25.81	5.16	1	9.13	9.13	3.97
5	Brown China-African	1	5.00	5.00	1	8.06	8.06	3.06
7	Toulouse-Embden	2	5.81	2.91	......	......	......	......
9	Brown China-Embden	5	22.63	4.53	......	......	......	......
11	Toulouse-Brown China	1	4.94	4.94	......	......	......	......
12	African-Brown China	7	33.19	4.74	4	30.00	7.50	2.76
13	White China-Embden	4	22.13	5.53	1	7.63	7.63	2.10
14	Brown China-Toulouse	9	49.88	5.54	2	16.41	8.20	2.66
15	Embden-African	3	15.94	5.31	......	......	......	......
17	African Pure	2	8.44	4.22	......	......	......	......
19	Embden Pure	1	4.13	4.13	1	6.81	6.81	2.68
22	White China-{Toulouse / Embden}	2	9.00	4.50	......	......	......	......

[1] Suffered loss from attack by dogs, June 22d and 29th.

TABLE VIII.—*Showing Weight of Goslings Hatched May 23d, 1896.—Third Hatch.*

Yard.	Mating.	Weight June 27, 35 Days Old.			Weight July 18, 56 Days Old.				Weight July 31, 69 Days Old.			
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
1	Toulouse-African.	1	3.00	3.00	1	4.19	4.19	1.19	1	7.13	7.13	2.94
2	Embden-Brown China.	1	3.13	3.13	1	5.69	5.69	2.56	1	7.31	7.31	1.62
3	Embden-Toulouse	4	12.66	3.17	4	26.33	6.58	3.41	4	32.28	8.07	1.49
5	Brown China-African.	2	5.31	2.66	2	10.19	5.10	2.44	2	13.75	6.87	1.77
6	Brown China Pure	2	5.06	2.53	2	10.25	5.13	2.60	2	13.06	6.53	1.40
8	African-Embden	3	10.63	3.54	3	20.88	6.96	3.42	3	25.69	8.56	1.60
9	Brown China-Embden	3	10.25	3.42	3	18.69	6.23	2.81	3	23.31	7.77	1.54
10	Embden-White China	1	2.94	2.94	1	6.00	6.00	3.06	1	7.31	7.31	1.31
11	Toulouse-Brown China	7	23.69	3.38	7	45.50	6.43	3.05	7	54.00	7.71	1.28
12	African-Brown China.	8	22.94	2.87	7	45.31	6.48	3.61	7	46.75	6.68	.20
13	White China-Embden.	1	2.63	2.63	1	5.38	5.38	2.75	1	6.50	6.50	1.12
14	Brown China-Toulouse	10	35.81	3.58	10	70.13	7.01	3.43	10	87.44	8.74	1.73
15	Embden-African	1	3.44	3.44	1	7.13	7.13	3.69	1	8.78	8.78	1.65
17	African Pure	4	13.75	3.44	4	29.13	7.28	3.84	4	36.88	9.22	1.94
21	White China-Toulouse	2	4.81	2.40	2	10.06	5.03	2.62	2	13.25	6.63	1.60

TABLE IX.—*Weights of Goslings Hatched June 4th, 1896.—Fourth Hatch,*

Yard.	Mating.	Weight July 3, 30 Days Old.			Weight July 30, 56 Days Old.				Weight Aug. 14, 71 Days Old.				Weight Nov. 2, 150 Days Old.			
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
1	Toulouse-African.	4	11.88	2.97	4	30.06	7.52	4.55	4	35.13	8.78	1.26	4	50.38	12.60	3.82
2	Embden-Brown China	4	9.69	2.42	4	25.69	6.42	4.00	4	29.69	7.42	1.00	4	40.06	10.02	2.60
3	Embden-Toulouse..	1	1.38	1.38	1	5.69	5.69	4.31	1	7.31	7.31	1.62	1	12.25	12.25	4.94
4	African-Toulouse..........	5	15.56	3.11	5	39.88	7.98	4.87	5	45.75	9.15	1.17	5	64.50	12.90	3.75
6	Brown China Pure..... ...	2	3.50	1.75	2	9.50	4.75	3.00	2	10.75	5.38	.63	2	15.81	7.91	2.53
9	Brown China-Embden......	1	2.13	2.13	...	.....	......	...	....	......	.....	....	....	......	....	. . .
10	Embden-White China.. ...	1	2.63	2.63	1	6.63	6.63	4.00	1	7.69	7.69	1.06	1	10.50	10.50	2.81
11	Toulouse-Brown China.....	3	8.38	2.79	3	19.75	6.58	3.79	3	22.19	7.30	.72	2	21.94	10.97	3.67
12	African-Brown China	8	19.88	2.48	8	52.07	6.51	4.03	8	58.13	7.27	.76	8	77.00	9.63	2.36
13	White China-Embden......	4	11.31	2.83	4	28.00	7.00	4.17	4	30.75	7.69	.69	4	42.88	10.72	3.03
14	Brown China-Toulouse. ...	4	12.88	3.22	4	31.69	7.92	4.70	4	36.81	9.20	1.28	4	53.94	13.49	4.29
15	Embden-African..........	4	12.31	3.08	4	31.38	7.85	4.77	4	37.56	9.39	1.54	4	53.69	13.42	4.03
17	African Pure.............	4	11.06	2.77	4	28.50	7.13	4.36	4	33.44	8.36	1.23	4	43.38	10.85	2.49
22	White China- { Toulouse. / Embden.. }	3	9.00	3.00	3	19.38	6.46	3.46	3	21.38	7.13	.67	3	27.88	9.29	2.16

TABLE X.—*Showing Weights of Goslings Hatched June 17th, 1896.—Fifth Hatch.*

Yard.	Mating.	Weight July 22, 35 Days Old.			Weight August 12, 56 Days Old.				Weight August 26, 70 Days Old.				Weight November 16, 151 Days Old.			
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
2	Embden-Brown China.	5	17.50	3.50	5	34.06	6.81	3.31	5	42.88	8.58	1.77	4	47.06	11.76	3.18
3	Embden-Toulouse.....	8	29.19	3.65	8	57.80	7.23	3.58	8	76.50	9.56	2.33	8	109.31	13.66	4.10
4	African-Toulouse......	3	13.06	4.35	3	25.50	8.50	4.15	3	33.75	11.25	2.75	3	45.75	15.25	4.00
5	Brown China-African..	3	9.50	3.17	3	17.88	5.96	2.79	3	23.75	7.92	1.96	3	30.88	10.29	2.37
8	African-Embden	7	31.88	4.55	7	60.38	8.63	4.08	7	74.06	10.58	1.95	7	99.56	14.22	3.64
9	Brown China-Embden.	4	17.25	4.31	4	28.50	7.13	2.82	4	36.31	9.08	1.95	4	44.56	11.14	2.06
11	Toulouse-Brown China	4	14.06	3.52	4	25.13	6.28	2.76	4	34.25	8.56	2.28	4	44.44	11.11	2.55
12	African-Brown China..	6	20.19	3.37	6	39.00	6.50	3.13	6	49.94	8.32	1.82	6	61.81	10.30	1.98
14	Brown China-Toulouse	6	24.75	4.13	6	46.50	7.75	3.62	6	60.75	10.13	2.38	6	86.06	14.34	4.21
15	Embden-African	2	9.44	4.72	2	17.44	8.72	4.00	2	22.44	11.22	2.50	2	29.44	14.72	3.50
16	White China Pure.....	1	2.94	2.94	1	5.81	5.81	2.87	1	6.94	6.94	1.13	1	8.75	8.75	1.81

TABLE XI.—*Showing the Weights of Goslings Hatched July 2nd, 1896.—Sixth Hatch.*

Yard No.	Mating.	Weight Aug. 10, 39 Days Old.			Weight Aug. 26, 55 Days Old.				Weight Sept. 11, 71 Days Old.				Weight Dec. 1, 151 Days Old.			
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
5	Brown China-African	1	3.13	3.13	1	6.13	6.13	3.00	1	7.25	7.25	1.12	1	8.88	8 88	1.63
9	Brown China-Embden......	1	5.00	5.00	1	8.50	8.50	3.50	1	10.56	10.56	2.06	1	12.56	12.56	2.00
11	Toulouse-Brown China.....	2	7.25	3.63	2	14.19	7 10	3.47	2	19.00	9.50	2.40	2	22.56	11.28	1.78
14	Brown China-Toulouse ..	6	22.94	3.82	6	42.00	7.00	3.18	6	55.56	9.26	2.26	6	79 00	13.16	3.90
17	African Pure..............	1	3.69	3.69	1	7.50	7.50	3.81	1	9 88	9.88	2.38	1	13.25	13.25	3.37
20	Toulouse-White China.....	1	2.63	2.63	1	6.13	6.13	3.50	1	8.13	8.13	2.00	1	10.75	10.75	2.62

NOTES ON THE TABLES.

The first period of growth began with the hatching of the goslings and extended to the time of the first weighing. It varied in length from 30 to 39 days, and, therefore, the amount of daily growth is the only just basis of comparison between the different hatches. No account is taken of the original weight of the gosling when hatched, but the average weight of the goslings from each mating is divided by the number of days, and the result in ounces given as daily growth.

First Period of Growth.

First Hatch (table VI).—At 35 days old the Brown China-Toulouse cross was heaviest, weighing 2.78 pounds, and the Embden-African second, with Toulouse-Brown China third, and nearly as heavy as the first. The best average daily growth was 1.27 ounces.

Second Hatch (table VII).—This hatch was weighed first at 39 days old, and was heavier in proportion to age than any other hatch, five of the crosses averaging 5 pounds or more each in weight. The heaviest was Brown China-Toulouse, then White China-Embden, Embden-African, African-Toulouse, and Brown China-African in the order named. The Toulouse-Embden cross was the lightest, weighing only 2.91 pounds. The daily growth averaged 2.27 ounces for the heaviest goslings.

Third Hatch (table VIII).—The goslings of this hatch were weighed first at 35 days old. The Brown China-Toulouse cross, of which there were 10 in this hatch, were heaviest, averaging 3.58 pounds in weight, equal to a daily growth of 1.63 ounces. African-Embden almost equaled the weight of the heaviest birds, and Embden-African, African pure, and Brown China-Embden were but little lower in weight.

Fourth Hatch (table IX).—These goslings were weighed first at

30 days old, and the heaviest was again a Brown China-Toulouse cross. The second in weight was African-Toulouse, and the third, Embden-African. The best daily growth was 1.71 ounces, made by the first named cross.

Fifth Hatch (table X).—The first weight was taken at 35 days old, and the Embden-African cross was found to be the heaviest; African-Embden, second, and African-Toulouse, third. The best average daily growth was made by the heaviest birds, and was 2.15 ounces.

Sixth Hatch (table XI).—Only five crosses and one pure bred were included in this hatch. A Brown China-Embden weighed most at 39 days old, and Brown China-Toulouse, and African pure were second and third. The daily growth of the heaviest averaged 2.05 ounces.

Second Period of Growth.

The second period ended when the goslings were about eight weeks old, and varied from 16 days to 26 days; four of the hatches being just 21 days between the weighings. The goslings were from 55 to 60 days old.

First Hatch (table VI).—The Brown China-Toulouse cross was heaviest, weighing 7.06 pounds, at 56 days old; African-Toulouse, African-Embden, and Embden-Brown China, were nearly of equal weights, and a trifle less than 6.50 pounds each. The first named cross made an average gain, for the 21 days of this period, of 3.26 ounces, but the greatest gain was made by an Embden-Brown China, viz.: 3.71 ounces per day.

Third Hatch (table VIII).—The pure bred Africans were heaviest at this weighing, having gained 3.84 pounds each in 21 days, or 2.92 ounces daily. The Embden-African cross was second to Africans, and the Brown China-Toulouse cross third. All other goslings failed to average 7 pounds each in weight.

Fourth Hatch (table IX).—African-Toulouse goslings were

heaviest at this weighing, with Brown China-Toulouse nearly equal to them in weight, and Embden-African and Toulouse-African crosses not far behind. The daily gain made by the first named cross was 2.99 ounces.

Fifth Hatch (table X). — The Embden-African cross was heaviest; African-Embdens, second, and African-Toulouse held the third place, and these three crosses were the only ones averaging over 8.5 pounds each. The next best weight was 7.75 pounds in the case of the Brown China-Toulouse cross, and all others were lower. The best daily gain was made by the African-Toulouse cross, and was 3.16 ounces.

Sixth Hatch (table XI).—The Brown China-Embden cross was again heaviest, with the pure bred African second, and Toulouse-Brown China third. The greatest gain was made by the African, and equaled 3.81 ounces daily.

Third Period of Growth.

The third weighing was made as nearly as possible at ten weeks old. The goslings were from 69 to 71 days old, and the time since the second weighing varied from 13 to 16 days.

First Hatch (table VI).—The heaviest birds at 70 days old were the Embden-Africans, which averaged 9.83 pounds. Embden-Brown China and Toulouse-African crosses occupied second and third places, and these were the only ones exceeding 9 pounds in average weight. The first named cross made the greatest gain, amounting to 4.28 ounces per day. The Brown China-Toulouse cross which made the greatest gain in the previous period of growth, made the poorest record in this, viz., 1.3 ounces per day.

Third Hatch (table VIII).—The pure bred Africans maintained their supremacy, and weighed 9.22 pounds at 69 days old, equal to a gain of 2.38 ounces daily in this period. The Embden-African, Brown China-Toulouse, and African-Embden crosses were next in weight in the order named, and all others had an average weight

of less than 8 pounds. The greatest daily gain, 3.61 ounces, was made by a Toulouse-African, which made the lowest gain in the second period.

Fourth Hatch (table IX).—The Embden-African cross, at 71 days old, weighed 9.39 pounds. The Brown China-Toulouse ranked second, and African-Toulouse third; all others were below 9 pounds each in average weight. The greatest gain made was 1.71 ounces per day by an Embden-Toulouse gosling.

Fifth Hatch (table X).—The African-Toulouse cross weighed 11.25 pounds, and only slightly exceeded the Embden-African birds, which weighed 11.22 pounds. The third place is held by the African-Embden cross. The heaviest birds made the greatest gain, 3.14 ounces daily.

Sixth Hatch (table XI).—As at the two previous weighings of this hatch, the Brown China-Embden was the heaviest bird, with pure bred African second, and Toulouse Brown-China third. The greatest gain was made by the last named cross, and amounted to 2.40 ounces daily.

Fourth Period of Growth.

The birds of the first hatch (and a few spared by the dogs from the second) were penned up for fattening four days after the third weighing, when 74 days old, and dressed for market about three weeks later. The third hatch was also penned for fattening when 73 days old, and dressed for market 26 days later. The fourth, fifth, and sixth hatches were kept until late fall and winter, and were weighed at 150 and 151 days old.

Fourth Hatch (table IX).—The Brown China-Toulouse and Embden-African crosses were nearly equal in weight, and the only ones exceeding 13 pounds each at 150 days old. The African-Toulouse cross was third in weight, almost reaching 13 pounds. The pure Brown Chinas weighed least of all, only 7.91 pounds. The greatest gain was made by the Embden-Toulouse cross,

and was just 1 ounce per day for the 79 days since the third weighing.

Fifth Hatch (table X).—The African-Toulouse cross were the heaviest birds, weighing 15.25 pounds each. Embden-African, Brown China-Toulouse, and African-Embden were next in rank in the order named, and the only ones exceeding 14 pounds in average weight. The pure White China weighing only 8.75 pounds. The greatest gain was made by the Brown China-Toulouse, and was equal to 0.83 of an ounce daily.

Sixth Hatch (table XI).—Pure bred Africans exceeded the others in weight, although the Brown China-Toulouse cross nearly equaled it, the weights of the two being 13.25 and 13.16 pounds respectively. The Brown China-Embden, which held the first place through the three previous weighings, now has the third place, weighing only 12.56 pounds. The greatest gain was made by the Brown China-Toulouse, and was 0.78 of an ounce daily.

In table XII is shown the heaviest average weight at each weighing, and the greatest daily gain with the matings which produced the heaviest birds.

TABLE XII.—*Showing Greatest Average Weights, and Daily Gains at each Weighing, and Matings which produced the Heaviest Three Average Weights.*

HATCH.	HEAVIEST AVERAGE WEIGHT.			2D HEAVIEST AVERAGE WEIGHT.		3D HEAVIEST AVERAGE WEIGHT.		GREATEST DAILY GAIN DURING THE PERIOD.		
	Yard.	Mating.	Pounds.	Yard.	Mating.	Yard.	Mating.	Ounces.	Yard.	Mating.
First Period.										
1st Hatch........	14	Brown China-Toulouse.	2.78	15	Embden-African........	11	Toulouse-Brown China.	1.27	14	Brown China-Toulouse.
2d "	14	" "	5.54	13	White China-Embden ..	15	Embden-African........	2.27	14	" "
3d "	14	" "	3.56	8	African-Embden........	15	" "	1.63	14	" "
4th "	14	" "	3.22	4	African-Toulouse	15	" "	1.71	14	" "
5th "	15	Embden-African.	4.72	8	African-Embden........	4	African-Toulouse	2.15	15	Embden-African.
6th "	9	Brown China-Embden..	5.00	14	Brown China-Toulouse.	17	African-African........	2.05	9	Brown China-Embden.
Second Period.										
1st Hatch........	14	Brown China-Toulouse.	7.06	4	African-Toulouse	8	African-Embden........	3.71	2	Embden-Brown China.
3d "	17	African-African........	7.28	15	Embden-African........	14	Brown China-Toulouse.	2.92	17	African-African
4th "	4	African-Toulouse	7.98	14	Brown China-Toulouse.	15	Embden-African........	2.99	4	African-Toulouse.
5th "	15	Embden-African........	8.72	8	African-Embden...	4	African-Toulouse	3.16	4	" "
6th "	9	Brown China-Embden..	8.50	17	African-African........	11	Toulouse-Brown China.	3.81	17	African-African.
Third Period.										
1st Hatch........	15	Embden-African........	9.83	2	Embden-Brown China..	1	Toulouse-African	4.28	15	Embden-African.
3d "	17	African-African........	9.22	15	Embden-African........	14	Brown China-Embden..	3.61	1	Toulouse-African.
4th "	15	Embden-African...... .	9.39	14	Brown China-Toulouse.	4	African-Toulouse	1.71	8	Embden-Toulouse.
5th "	4	African-Toulouse	11.25	15	Embden-African........	8	African-Embden	3.14	4	African-Toulouse.
6th "	9	Brown China-Embden..	10.56	17	African-African........	11	Toulouse-Brown China.	2.40	11	Toulouse-Brown China.
Fourth Period.										
4th Hatch.......	14	Brown China-Toulouse.	13.49	15	Embden-African........	4	African-Toulouse	1.00	3	Embden-Toulouse.
5th "	4	African-Toulouse	15.25	15	" "	14	Brown China-Toulouse.	0.88	14	Brown China-Toulouse.
6th "	17	African-African........	13.25	14	Brown China-Toulouse.	9	Brown China-Embden..	0.78	14	" "

By examining this table we find that nineteen weighings have been made, and that pen 14, Brown China-Toulouse goslings, have been heaviest 6 times; second heaviest 4 times; third heaviest 3 times, and made the greatest daily gain 6 times. Number 15, Embden-African goslings, have ranked first 4 times; second, 6 times; third, 4 times, and made the greatest daily gain 2 times. Number 4, African-Toulouse, has held first place 3 times; second place 2 times; third place 4 times, and made the greatest daily gain 3 times. Number 17, pure bred Africans, have been the heaviest birds 3 times; second in weight 2 times; third, 1 time, and made the greatest daily gains 2 times. The other numbers represented in this honor list in a more scattering way are 1, 2, 3, 8, 9, 11, and 13; while the numbers not once represented are 5, 6, 7, 10, 12, 16, 19, 20, 21, and 22. The lowest average weights were made by No. 6, Brown China pure, 5 times; No. 16, White China pure, 4 times; No. 5, Brown China-African, 3 times; No. 20, Toulouse-White China, 2 times; No. 3, Embden-Toulouse, 2 times; and the following crosses once each—Toulouse-African, Toulouse-Embden, White China-Embden, and White China-Toulouse.

In tables XIII, XIV, XV, and XVI we have combined the different hatches, so as to obtain the average figures for all the goslings raised from each mating; the total number of goslings of each kind, weighed at the end of each period of growth; the total and average weight of the goslings from each mating; the total, number of days' growth, and the average daily growth. The number of days' growth was found by multiplying the days from date of hatching to time of weighing by the number of goslings in each hatch separately, and adding the results together. The total weight of the goslings divided by the total days in each case gives the average daily growth from time of hatching to time of weighing. In these calculations the weight of the goslings when hatched is included in the daily growth.

TABLE XIII.—*First Weighing, Goslings 30–39 Days Old, 1896.*

YARD No.	MATING.	No. of goslings.	Total No. of days' growth.	Total weight Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1	Toulouse–African.......	12	416	40.57	3.38	1.560
2	Embden–Brown China..	13	443	39.57	3.04	1.428
3	Embden–Toulouse	15	414	49.17	3.27	1.899
4	African–Toulouse.......	22	765	75.43	3.42	1.577
5	Brown China–African...	9	323	27.69	3.07	1.371
6	Brown China Pure	5	165	9.87	1.97	0.956
7	Toulouse–Embden	4	148	9.19	2.29	0.992
8	African–Embden.	16	560	55.89	3.49	1.568
9	Brown China–Embden .	19	684	68.64	3.61	1.604
10	Embden–White China..	2	65	5.57	2.78	1.369
11	Toulouse–Brown China.	22	767	69.76	3.17	1.454
12	African–Brown China...	40	1,388	121.58	3.03	1.401
13	White China–Embden...	9	311	36.07	4.00	1.854
14	Brown China–Toulouse..	37	1,285	151.76	4.11	1.966
15	Embden–African........	21	727	71.01	3.38	1.584
16	White China Pure	2	70	4.82	2.41	1.100
17	African Pure............	17	587	50.94	2.99	1.387
19	Embden Pure...........	1	35	4.13	4.13	1.888
20	Toulouse–White China..	1	39	2.63	2.63	1.078
21	White China–Toulouse..	2	70	4.81	2.40	1.099
22	Wh. China-{Toulouse / Embden..}	5	168	18.00	3.60	1.713

TABLE XIV.—*Second Weighing, Goslings 55-60 Days Old, 1896.*

YARD No.	MATING.	No. of goslings.	Total No. of days' growth.	Total weight. Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1	Toulouse–African......	9	508	62.01	6.89	1.952
2	Embden–Brown China ..	11	616	71.88	6.53	1.865
3	Embden–Toulouse......	14	784	94.87	6.77	1.936
4	African–Toulouse......	18	1,012	132.96	7.38	2.100
5	Brown China–African...	9	507	54.76	6.08	1.728
6	Brown China Pure......	5	280	24.00	4.80	1.371
7	Toulouse–Embden......	1	56	5.75	5.75	1.635
8	African–Embden........	16	836	130.01	8.12	2.488
9	Brown China–Embden...	13	727	84.88	6.53	1.867
10	Embden–White China..	2	112	12.63	6.10	1.803
11	Toulouse–Brown China..	21	1,202	135.07	6.43	1.796
12	African–Brown China ..	36	2,032	232.63	6.46	1.830
13	White China–Embden..	6	340	41.01	6.83	1.929
14	Brown China–Toulouse..	30	1,682	220.86	7.36	2.195
15	Embden–African..	18	1,008	122.87	6.82	1.948
16	White China Pure......	2	112	10.81	5.40	1.544
17	African Pure..........	15	839	101.63	6.77	1.937
19	Embden Pure.	1	60	6.81	6.81	1.816
20	Toulouse–White China..	1	55	6.13	6.13	1.783
21	White China–Toulouse..	2	112	10.06	5.03	1.436
22	Wh. China- {Toulouse. / Embden. }	3	168	19.38	6.46	1.844

TABLE XV.—*Third Weighing, Goslings 69–71 Days Old, 1896.*

YARD No.	MATING.	No. of goslings.	Total No. of days' growth.	Total weight. Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1	Toulouse–African	8	563	40.38	8.79	2.000
2	Embden–Brown China	11	773	89.44	8.13	1.851
3	Embden–Toulouse	14	977	122.47	8.74	2.004
4	African–Toulouse	15	1,055	141.88	9.45	2.150
5	Brown China–African	7	489	52.31	7.47	1.710
6	Brown China Pure	4	280	23.81	5.95	1,360
8	African-Embden	14	977	133.50	9.53	2.185
9	Brown China–Embden	12	838	102.74	8.56	1.960
10	Embden–White China	2	140	15.00	7.50	1.713
11	Toulouse–Brown China	21	1,468	167.63	7.98	1.825
12	African–Brown China	31	2,171	232.82	7.51	1.715
13	White China–Embden	5	353	37.25	7.45	1.688
14	Brown China–Toulouse	28	1,960	256.97	9.17	2.097
15	Embden–African	16	1,123	157.28	9.83	2.240
16	White China Pure	1	70	6.94	6.94	1.585
17	African Pure	14	981	122.95	8.78	2.004
20	Toulouse–White China	1	71	8.13	8.13	1.832
21	White China–Toulouse	2	138	13.25	6.63	1.536
22	Wh. China-{Toulouse / Embden.}	3	213	21.38	7.13	1.604

TABLE XVI.—*Fourth Weighing, Goslings 150-151 Days Old, 1896.*

YARD No.	MATING.	No. of goslings.	Total No. of days' growth.	Total weight. Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1	Toulouse-African......	4	600	50.38	12.60	1.342
2	Embden-Brown China..	8	1,204	87.12	10.89	1.156
3	Embden-Toulouse......	9	1,358	121.56	13.50	1.432
4	African-Toulouse.......	8	1,203	110.25	13.78	1.465
5	Brown China-African...	4	604	39.76	9.94	1.052
6	Brown China Pure......	2	300	15.81	7.91	0.843
8	African-Embden.......	7	1,057	99.56	14.22	1.505
9	Brown China-Embden..	5	755	57.12	11.42	1.209
10	Embden-White China...	1	150	10.50	10.50	1.120
11	Toulouse-Brown China..	8	1,206	88.94	11.12	1.179
12	African-Brown China...	14	2,106	138.81	9.91	1.054
13	White China-Embden...	4	600	42.88	10.72	1.142
14	Brown China-Toulouse..	16	2,412	219.00	13.68	1.451
15	Embden-African........	6	902	83.18	13.85	1.473
16	White China Pure	1	151	8.75	8.75	0.926
17	African Pure............	5	751	56.63	11.32	1.206
20	Toulouse-White China..	1	151	10.75	10.75	1.192
22	Wh. China-{Toulouse / Embden.}	3	450	27.88	9.29	0.990

GREATEST DAILY GAINS.

The greatest daily gain up to 39 days old was made by the Brown China-Toulouse cross. At 60 days old the African-Embden cross had won first place, but yielded it to the Embden-African cross at 71 days' growth, and again took first place at 151 days old.

As these tables include all the goslings produced during the season, covering six different dates of hatching, the figures necessarily give a pretty just comparison of the rates of growth of the different crosses.

The mating for pure bred Toulouse goslings was a failure, and such a limited number of goslings were raised from the pure Embdem and pure White China matings that comparisons of the rate of growth of the pure breeds is hardly fair at this time. We take from the tables and arrange together the four matings making the best daily gains at each weighing. In only one case did any of the pure breeds make sufficient gain to secure a place in the list, but at the third weighing Africans tied with the Embden-Toulouse cross for the fifth place and just exceeded the gain made by the Toulouse-African cross.

Four best daily gains at different ages:

First Weighing, Goslings 30 to 39 Days Old.

Yard	14	Brown China-Toulouse cross, first,	1.966	ounces
"	3	Embden-Toulouse cross, second,	1.899	"
"	19	Embden, pure bred, third,	1.888	"
"	18	White China-Embden cross, fourth,	1.854	"

Second Weighing, Goslings 55 to 60 Days Old.

Yard	8	African-Embden cross, first,	2.488	ounces.
"	14	Brown China-Toulouse cross, second,	2.195	"
"	4	African-Toulouse cross, third,	2.100	"
"	1	Toulouse-African cross, fourth,	1.952	"

Third Weighing, Goslings 69 to 71 Days Old.

Yard 15	Embden-African cross, first,	2.240 ounces.
" 8............	African-Embden cross, second,	2.185 "
" 4............	African-Toulouse cross, third,	2.150 "
" 14	Brown China-Toulouse cross, fourth,	2.097 "

Fourth Weighing, Goslings 150 to 151 Days Old.

Yard 8.	African-Embden cross, first,	1.505 ounces.
" 15............	Embden-African cross, second,	1.473 "
" 4............	African-Toulouse cross, third,	1.465 "
" 14............	Brown China-Toulouse cross, fourth,	1.451 "

The smallest gain at each of the four weighings was as follows:

First weighing,	Yard 6.........	Brown China, pure bred,	0.956 ounces.
Second "	" 6.........	" " " "	1.371 "
Third "	" 6.........	" " " "	1.360 "
Fourth "	" 6.........	" " " "	0.843 "

Pure White China ranked next to Brown China in giving a small daily gain.

FATTENING.

On July 8th, when the goslings of the first hatch were 74 days old, they were penned up for fattening. A few goslings of the second hatch, which had associated with them after the attack by dogs, were also included, although 10 days younger. The pen was on the brow of a sandy knoll from which water would drain rapidly, and was about 35 feet square. The fence was made of wire netting four feet wide with two feet of boards at the bottom, making a fence six feet high. Shade was afforded by a shelter of birches laid upon poles about two feet from the ground. Water for drinking was provided in pails, and their food was placed upon board troughs laid on the ground. Cracked oyster shells and gravel were kept in the pen where they could help themselves at any time. Charcoal was fed to them twice a week. After one

or two days of moderate feeding, to get the 60 goslings placed in the pen accustomed to their quarters, they were fed morning and night upon dough made from one part freshly ground beef scraps of the best quality and four parts sweet Indian corn meal by measure, seasoned with a little salt and mixed with boiling water. Whole corn was fed at noon. The preparation of the food and feeding was substantially as recommended under the head of "Fattening," on pages 467–470. August 1st, 57 of the goslings were dressed for market—three pure bred Africans being retained for breeding purposes. The 57 goslings were killed and picked in a little more than ten hours, by two professional pickers. The live weight of each bird was recorded and also placed on a wooden label attached to the leg, so that, after being thoroughly cooled in ice-water, the dressed weight could be compared with it. The color of the feathers, the color of the bill and nail at the point of the beak, and of the legs and claws, was noted, and some observations on the ease or difficulty of picking the different crosses. The operation of dressing, icing, and shipping to market has already been described on pages 470–474, and need not be repeated.

The goslings were divided into two lots, each representing as far as possible all the crosses dressed, and sent by express to two wholesale poultry dealers for sale. They were asked, and kindly consented, to give an opinion upon the merits of the goslings sent, each of which bore a tag with the pen number, but no other mark. One lot was sent to Messrs W. H. Rudd, Son & Co, of Boston, Mass., and the other to Messrs Knapp & Van Nostrand, of New York.

July 4th, four days before they were put in the fattening pen, the goslings of the first hatch averaged 8.57 pounds each, and were 70 days old. When killed, August 1st, 57 goslings—50 of which were 97 days old, and 7 only 87 days old—weighed 657.06 pounds, or an average of 11.52 pounds, showing an average gain in live weight of 2.95 pounds, equal to a daily gain of 1.75 ounces. Their total dressed weight was 632.19 pounds, or an average of 11.09 pounds. The total dressed weight was 96.21 per cent. of the total live weight.

On August 3d the third hatch of goslings was put into the fattening pen and the same course pursued as in the case of the first hatch. They were fed until August 29th, when 45 were dressed by the same pickers and shipped to the same commission merchants, as in the case of the first lot: 25 were shipped to Boston, and 20 to New York. This lot was 72 days old when shut up for fattening, and when 69 days old 49 goslings weighed alive 383.44 pounds, or an average of 7.82 pounds each. When dressed, they were 98 days old, and 45 of them weighed 488.69 pounds—an average of 10.86 pounds each, showing a gain of 3.04 pounds in 29 days, or a daily gain of 1.67 ounces. The total dressed weight of the 45 goslings was 473.44 pounds, equal to an average of 10.52 pounds. The total dressed weight was 96.87 per cent. of the total live weight.

TABLE XVII.—*Showing Live and Dressed Weights of 1st and 2d Hatch Goslings Killed August 1st, 1896, with Comments of Commission Merchants, and Notes relating to Color, etc.*

Yard No.	Mating.	Live weight. Pounds.	Dressed weight. Pounds.	Estimate of Quality by Commission Merchants.	Notes Relating to Color, Etc.
1	Toulouse-African......	13.88	13.44	B. Good birds, but appearance is against them. N. Y. Classed No. 3.	All dark colored birds. One was Toulouse type, and four African type with stripe on neck. Greenish yellow bills with black nail at tip, light yellow legs with black claws. Pick good.
"	" "	11.94	11.19		
"	" "	9.94	9.81		
"	" "	12.68	12.06		
"	" "	13.75	12.63		
	Average.............	12.43	11.72		
2	Embden-Brown China.	12.69	12.38	B. A fine bird.	White, slightly pied, pick good, yellow bill and legs, white nail and claws.
3	Embden-Toulouse......	10.44	10.00	B. Good salable size.	White, slightly pied, pick good, yellow bill and legs, white nail and claws.
4	African-Toulouse......	9.00	8.69	B. Good plump stock, about like No. 1. N. Y. Classed No. 4.	All dark birds. Resemble African more than Toulouse, pick hard, skin inclined to tear in picking. Greenish yellow bills and legs, with black nail and black claws.
"	" "	13.13	12.31		
"	" "	10.88	10.75		
"	" "	12.68	12.19		
"	" "	13.56	12.81		
"	" "	14.44	13.88		
"	" "	12.44	12.13		
"	" "[1]......	12.69	12.50		
	Average.............	12.34	11.90		
8	African-Embden.......	10.13	9.75	B. One bird best of all, others not as good. Equal to No. 15. N. Y. Classed No. 2.	Two light drab and two pied birds, pick easily. Yellow or greenish yellow bills with dark or black nail, legs same color. Three birds had black claws and one white ones.
"	" "	12.75	12.25		
"	" "	9.94	9.63		
"	" "	12.68	11.81		
	Average.............	11.36	10.86		
9	Brown China-Embden.	10.88	10.38	B. Quality fair. N. Y. Classed No. 4.	Three birds pied and one drab, with light stripe on the neck; latter had dark bill, black nail, greenish yellow legs and black claws. Two pied birds had yellow bills and legs, white nails and claws; the other had yellow bill and legs but black nail, and claws striped with black. Pick good.
"	" "	9.69	9.31		
"	" "	10.50	10.06		
"	" "	11.94	11.44		
	Average.............	10.75	10.29		
11	Toulouse-Brown China.	9.13	8.75	B. Not recommended. N. Y. Classed No. 4.	All dark birds, inclining to Brown China type. Yellow or greenish yellow bills and legs, with black nails and claws. Pick easily.
"	" "	10.81	10.63		
"	" "	10.38	9.81		
"	" "	9.88	9.69		
"	" "	10.69	10.44		
	Average.............	10.18	9.86		

[1] Second hatch bird.

TABLE XVII.—*Continued.*

Yard No.	Mating.	Live weight. Pounds.	Dressed weight. Pounds.	Estimate of Quality by Commission Merchants.	Notes Relating to Color, etc.
12	African-Brown China.[1]	12.44	11.75	B. Preferred to No. 11, but appearance is against them. N. Y. Classed No. 4.	All dark colored birds, with dark stripe on back of neck. Almost or quite black bills with black nail, greenish yellow legs with black claws. Pick easily.
"	" "	9.44	9.25		
"	" "	9.50	9.50		
"	" "	9.81	9.00		
"	" "	10.44	10.06		
"	" "	9.00	8.75		
"	" "	11.06	10.88		
"	" "	9.94	9.94		
"	" "[1]	10.06	10.00		
"	" "	11.18	10.56		
"	" "[1]	8.50	8.38		
"	" "	9.56	9.38		
	Average............	10.08	9.78		
13	White China-Embden[1].	9.44	9.44	B. Fair quality.	White, bright yellow bill and legs, white nail and claws. Pick very easily.
14	Brown China-Toulouse[1]	10.19	9.81	B. Second best lot. N. Y. Classed No. 4.	Drab colored, with stripe on neck, but not so dark as No. 12. Greenish or pale yellow bills and legs, black nails and claws. Pick fair.
"	" "	11.56	11.44		
"	" "	10.25	9.81		
"	" "	11.81	10.63		
	Average............	10.82	10.42		
15	Embden-African.......	13.38	12.88	B. All good birds, probably the best cross. N. Y. Classed No. 1.	Three white and six pied—drab and white. Rich yellow bills and legs, white nails and claws. Pick very good, but skin on some a little tender.
"	" "	11.19	10.81		
"	" "	14.31	13.56		
"	" "	13.06	12.50		
"	" "	13.63	13.31		
"	" "	15.69	14.88		
"	" "	15.00	14.50		
"	" "	15.94	15.50		
"	" "	14.13	13.31		
	Average............	14.08	13.47		
17	African-African........	10.63	10.00	B. Not recommended. N. Y. Classed No. 2.	Pure Africans. Picked hard. Black bills and olive green legs, black nail and claws.
"	" "	13.81	13.88		
	Average............	12.22	11.69		
19	Embden-Embden[1].....	9.13	8.81	B. Not recommended.	Pure Embden. White, with yellow bill and legs, white nail and claws.

[1] Second hatch bird.

TABLE XVIII.—*Showing Live and Dressed Weights of 3d Hatch Goslings Killed August 29th, 1896, with Comments of Commission Merchants, and Notes Relating to Color, etc.*

Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	ESTIMATE OF QUALITY BY COMMISSION MERCHANTS.	NOTES RELATING TO COLOR, ETC.
1	Toulouse-African......	10.25	10.00	B. Below the usual grade received.	African type. Black bill and nail, greenish orange legs, black claws.
2	Embden-Brown China.	9.25	9.13	B. Below the usual grade received.	Nearly white. Yellow or orange bill and legs, white nail and claws.
3	Embden-Toulouse......	10.00	9.63	B. Good stock. N. Y. Very good stock. Classed No. 1.	White or slightly pied. Orange bills and legs, with white nails and claws. Pick very good.
"	" "	13.00	12.50		
"	" "	10.81	10.50		
"	" "	11.88	11.31		
"	" "	12.81	12.19		
	Average.............	11.70	11.22		
5	Brown China-African..	9.63	9.19	B. Below the usual grade received. N. Y. Poor, and will not sell on this market unless pushed.	Dark feathers and stripe on neck. Pick hard. Bills dark or black, legs greenish yellow, with black claws. Black nail at point of bill.
"	" " ..	8.50	8.31		
	Average.............	9.06	8.75		
8	African-Embden.......	10.75	10.00	B. Two best birds in the lot. N. Y. Fair.	Drab—faint stripe. Bills greenish yellow with black nails, legs same with black claws. Pick fair.
"	" "	10.94	10.56		
"	" "	11.35	11.00		
	Average.............	11.02	10.52		
9	Brown China-Embden.	9.69	9.69	B. Below the usual grade received.	One white and two pied birds. Orange bills and legs, with white nails and claws. Pick fair.
"	" "	11.25	10.69	N. Y. Fair.	
"	" "	10.38	9.88		
	Average.............	10.44	10.09		
10	Embden-White China..	10.50	10.13	B. Below the usual grade received.	White. Orange bill and legs, white nail and claws. Pick good.
11	Toulouse-Brown China[1]	10.69	11.00	B. All good stock, one bird *very good.*	One dark bird, all the rest slate color, with faint stripe on neck or none at all. Greenish yellow bills and legs, black nails and claws. Pick fair to good.
"	" "	10.56	10.13		
"	" "	10.31	10.00		
"	" "	9.38	9.06		
"	" " [1]	9.75	9.75	N. Y. Fair.	
"	" "	9.94	9.81		
"	" "	11.13	10.63		
	Average.............	10.25	9.98		

[1] Birds probably gained weight by soaking in ice water. It occasionally happens that a bird weighs more after being twenty-four hours in ice water than it did alive.

TABLE XVIII.—*Continued.*

Yard No.	Mating.	Live weight. Pounds.	Dressed weight. Pounds.	Estimate of Quality by Commission Merchants.	Notes Relating to Color, etc.
12	African-Brown China..	8.50	8.44	B. Below the usual grade received. N. Y. Fair.	Two had dark stripe on head and neck, and four a lighter stripe. All but one had black bills, exception was yellowish. Greenish yellow legs, black nails and claws. Pick fair to hard.
"	" " ..	13.69	12.88		
"	" " ..	9.13	8.81		
"	" " ..	7.81	7.81		
"	" " ..	8.94	8.63		
"	" " ..	9.81	9.63		
	Average.............	9.64	9.36		
13	White China-Embden..	8.25	8.19	B. Below the usual grade.	Pied, mostly white. Orange bill and legs, white nail and claws.
14	Brown China-Toulouse.	10.19	9.94	B. All good stock. Two *very good* birds. N. Y. Fair.	All dark feathered; faint stripe on neck; one with orange rim around the eye. One black bill, two greenish yellow, and seven yellow, all with black nails; legs greenish yellow; one with white, and the rest with black claws. Pick fair to hard.
"	" "	15.06	14.50		
"	" "	12.88	12.06		
"	" "	12.56	12.38		
"	" "	10.94	10.63		
"	" "	13.88	13.13		
"	" "	11.50	11.06		
"	" "	14.19	13.88		
"	" "	11.06	10.63		
"	" "	10.94	10.50		
	Average.............	12.27	11.87		
15	Embden-African.......	12.13	11.88	N. Y. Classed No. 1.	Pied. Light yellow bill, yellow legs, white nail and claws.
17	African-African........	13.19	12.69	B. One of the best. N. Y. Fair.	Pure Africans. Pick hard.
"	" "	12.50	11.94		
	Average.............	12.84	12.31		
21	White China-Toulouse.	11.69	11.56	B. Below the grade usually received. N. Y. Poor, will not sell on this market unless pushed.	One dark with few white feathers, other dark with white breast. Greenish yellow bills and legs, black nails and white claws.
"	" " [1]	7.63	7.75		
	Average.............	9.66	9.65		

While both hatches were dressed by the same pickers, who made a regular business of dressing goslings and other poultry, and an effort was made to pick all the crosses equally well, some of them were criticised for the presence of pin-feathers, especially the dark feathered birds, in which every one left was visible. One ship-

[1] Birds probably gained weight by soaking in ice water. It occasionally happens that a bird weighs more after being twenty-four hours in ice water than it did alive.

ment, August 3d, from the first hatch, brought 16 cents per pound for the shipment, although even lots of the best grade would have commanded a little more, and entire lots of the poorer grades considerable less. The other shipment brought 15 cents per pound for all grades, and full shipments of the poorer grades would have brought less. Both the lots shipped August 31st brought 14 cents per pound for all but two birds of the lowest grade, for which 11 cents per pound was allowed.

The pickers like best to dress white or pied geese, and usually find the Brown China type hard to pick. Much, however, depends upon the condition of the feathers in respect to growth; if well developed, the bird picks much easier than if only partly matured. If goslings are kept beyond 17 to 20 in the fattening pen, they are liable to begin to moult, and if so, the feathers will not again be in a satisfactory condition for picking until six or more weeks later.

The Embden-Africàn cross, No. 15, was classed No. 1 in both shipments, and the opposite mating, African-Embden, was almost equal to it. Embden-Toulouse birds were also classed as No. 1. All these crosses usually have yellow bills and orange legs. Pure Africans were not classed as equal to the above named crosses in quality. The African-Brown China, No. 12, and the Brown China-Toulouse, No. 14, were prolific and hardy and considerable many goslings were raised, but their appearance was not equal to the best crosses. The Brown China-African cross, met with as little favor as any. The Toulouse-Brown China cross, No. 11, was better received in the second shipments than in the first. They averaged somewhat smaller than when bred from the opposite mating, No. 14, and were not so satisfactory. The African-Toulouse cross, No. 4, and the opposite, No. 1, made birds of good size and fairly early maturity, but not so handsome in appearance when dressed as Embden crosses. Table XIX gives the average live and dressed weights of the first and third hatches, the per cents. of dressed to live weights, and the total and daily gains during the fattening period:

TABLE XIX.—*Showing Total and Daily Gains Made by Goslings in 1st and 3d Hatches in 1896, During Fattening Period, and Per Cent. of Dressed to Live Weight.*

Yard No.	Mating.	Hatch.	No. of goslings.	Average live weight at time of dressing. Pounds.	Average gain in fattening period. Pounds.	Average daily gain in ounces.	Average dressed weight. Pounds.	Per cent. of dressed to live weight.
1	Toulouse-African.....	1st	5	12.48	3.05	1.81	11.72	95.7
1	" "	3rd	1	10.25	3.12	1.72	10.00	
2	Embden-Brown China ..	1st	1	12.69	3.13	1.85	12.38	98.0
2	" " ..	3rd	1	9.25	1.94	1.07	9.13	
3	Embden-Toulouse......	1st	1	10.44	4.06	2.40	10.00	95.8
3	" "	3rd	5	11.70	4.25	2.34	11.22	
4	African-Toulouse.......	1st	8	12.34	3.43	2.03	11.90	96.4
5	Brown China-African...	3rd	2	9.06	2.19	1.20	8.75	96.5
8	African-Embden........	1st	4	11.36	2.92	1.73	10.86	95.5
8	" "	3rd	3	11.02	2.46	1.35	10.52	
9	Brown China-Embden ..	1st	4	10.75	2.61	1 54	10.29	96.1
9	" " ..	3rd	3	10.44	2.67	1.47	10.09	
10	Embden-White China...	3rd	1	10.50	3.19	1.76	10.13	96.4
11	Toulouse-Brown China..	1st	5	10.18	2.50	1.48	9.86	97.1
11	" " ..	3rd	7	10.25	2.54	1.40	9.98	
12	African-Brown China...	1st	12	10.03	2.23	1.32	9.78	97 3
12	" " ...	3rd	6	9.64	2.96	1.63	9 36	
13	White China-Embden...	2nd	1	9.44	1.94	1.15	9.44	99.6
13	" " ...	3rd	1	8.25	1.75	0 96	8.19	
14	Brown China-Toulouse..	1st	4	10.82	2.62	1.55	10.42	96.5
14	" " ..	3rd	10	12.27	3.53	1.94	11.87	
15	Embden-African........	1st	9	14.03	4.20	2.48	13.47	96.9
15	" "	3rd	1	12.13	3.35	1.84	11.88	
17	African-African	1st	2	12.22	3.32	1.96	11.69	95.7
17	" "	3rd	2	12.84	3.62	1.99	12.31	
19	Embden-Embden.......	2nd	1	9.13	2.32	1.37	8.81	96.4
21	White China-Toulouse..	3rd	2	9.66	3.03	1.67	9.65	99.8

Number 3, Embden-Toulouse, made a little better gain in the fattening pen than No. 15, Embden-African, but both made over two ounces gain per day. Africans, pure bred, No. 17, lacked only a little of making an average of two ounces in daily gains.

MATURE GOSLINGS.

All the other goslings raised in 1896 were kept until the fall and winter months, when the crosses were all fattened and dressed and the few pure breds reserved for breeding. Representatives of nearly all the crosses were shown alive and dressed at the annual show of the R. I. Poultry Association, held at Westerly, early in December. After selecting those for exhibition, those remaining were placed in the fattening pen, and at the end of the month they were dressed and shipped to New York. The crosses exhibited alive at Westerly were not fattened until some time after their return, and were dressed February 16th and 17th. These goslings were classed as old geese, and brought only a low price. Goslings to bring a remunerative price should be sold as green geese, or fattened and sold for freezing not later than November. The live and dressed weights of these goslings are given in the following tables:

TABLE XX.—*Showing Live, Dressed and Average Weights of Mature Goslings, with Notes Upon Color of the Different Crosses.*

Date when dressed.		Pen No.	MATING.	Live weight. Pounds	Dressed weight. Pounds.	NOTES UPON COLOR, ETC
Dec.	7.	1	Toulouse-African.	16.63	15.31	Plumage dark. African type. Bills and legs yellow. Black nails and claws Pick hard, tear easily.
"	"	1	" "	13.75	13.25	
			Average	15.19	14.28	
Dec.	7.	2	Embden-Brown China	14.94	13.88	Two white, one pied. All yellow bills and legs. White nails and claws. Pick fair to good.
"	"	2	" " ..	10.44	9.81	
"	18.	2	" " ..	12.25	11.38	
			Average	12.54	11.75	
Dec.	18.	3	Embden-Toulouse	14.44	13.50	Pied but nearly white, occasional dark feathers. Orange or yellow bills and legs, with white nails and claws. Easy to pick and of fine appearance when dressed.
"	"	3	" "	13.31	12.69	
"	"	3	" "	13.69	12.25	
"	"	3	" "	13.94	13.19	
"	7.	3	" "	16.50	15.31	
"	"	3	" "	16.50	15.31	
Nov.	3.	3	" "	12.50	13.25	
			Average	14.41	13.64	
Dec.	7.	4	African-Toulouse	15.88	14.75	Dark. African type. Mottled bills, pale yellow legs, black nails and claws. Very hard to pick.
Nov.	3.	4	" "	14.56	14.31	
			Average	15.22	14.53	
Nov.	3.	5	Brown China-African ..	14.06	14.06	Dark. Brown China type. Bills black, legs greenish yellow, tails and claws black. Pick hard, skin tears easily.
Dec.	7.	5	" " ...	10.56	10.25	
"	"	5	" " ...	9.88	9.25	
			Average	11.50	11.18	

TABLE XX.—*Continued.*

Date when dressed.		Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	NOTES UPON COLOR, ETC.
Dec.	7.	8	African-Embden........	15.25	14.19	Two African type, two pied. Bills yellow, or greenish yellow, with black or mottled nails; two claws black in one instance, and four white. Pick fair.
"	"	8	" "	16.06	15.00	
"	18.	8	" "	15.19	14.38	
"	"	8	" "	13.75	12.63	
			Average	15.06	14.05	
Nov.	3.	9	Brown China-Embden ..	13.06	13.00	Pied, orange bills and legs. White nails and claws. Pick fair.
"	"	9	" " ..	12.88	12.63	
Dec.	7.	9	" " ..	12.75	11.88	
			Average	12.96	12.50	
Dec.	7.	10	Embden-White China...	11.69	11.13	White, orange bill and legs, white nails & claws.
Dec.	7.	11	Toulouse-Brown China..	12.81	12.13	Brown China type with stripe on neck. Yellow bills and legs. One had black nail.
"	"	11	" " ..	10.81	9.94	
			Average	11.81	11.03	
Dec.	7.	12	African-Brown China...	8.25[1]	9.88[1]	Br. China type. Dark stripe on neck. Black bills and nails. Yellow or greenish yellow legs, with black claws. Some picked hard, others fair and good.
Nov.	3.	12	" " ...	10.81	10.81	
Dec.	7.	12	" " ...	11.88	11.00	
"	18.	12	" " ...	10.25	9.63	
"	"	12	" " ...	9.63	9.06	
"	"	12	" " ...	10.75	10.19	
"	"	12	" " ...	10.50	9.88	
"	28.	12	" " ...	11.25	10.50	
			Average	10.72	10.15	

[1] Error not included in the average.

TABLE XX.—*Continued.*

Date when dressed.		Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	NOTES UPON COLOR, ETC.
Nov.	3.	13	White China-Embden...	12.75	12.38	
Dec.	7.	13	" " ...	10.38	9.56	Pied, one nearly white. Orange or yellow bills and legs, with white nails and claws.
"	"	13	" " ...	10.94	10.00	
			Average	11.35	10.64	
Nov.	3.	14	Brown China-Toulouse..	17.56	17.00	
"	"	14	" " ..	16.69	16.13	
"	"	14	" " ..	17.00	16.88	
Dec.	7.	14	" " ..	17.25	16.06	
"	"	14	" " ..	16.38	15.25	
"	18.	14	" " ..	12.44	12.56	All dark birds. Three had yellow bills mottled with black, the rest yellow bills, all with black nails. Legs yellow, and claws black. Pick fair.
"	"	14	" " ..	17.75	17.00	
"	"	14	" " ..	17.94	16.94	
"	"	14	" " ..	16.88	15.75	
"	"	14	" " ..	14.44	13.50	
"	"	14	" " ..	12.00	11.63	
"	"	14	" " ..	16.50	15.25	
			Average	16.06	15.32	
Dec.	7.	15	Embden-African........	13.75	12.94	
"	"	15	" "	16.44	15.50	One white, two pied. Bills and legs yellow. One with mottled nail and claws, the others were white.
"	18.	15	" "	12.31	11.44	
			Average	14 16	13.29	

TABLE XXI.—*Showing Live, Dressed and Average Weights of Mature Goslings, and Notes Relating to Color, Etc.*

Date.	Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	NOTES ON COLOR, ETC.
Feb. 16.[1]	1	Toulouse–African.......	15.81	15.69	Dark. Inclined to African type. One with yellow bill and legs. Pick rather hard.
" "	1	" "	15.81	15.38	
		Average	15.81	15.53	
Dec. 28.[2]	2	Embden–Brown China ..	12.13	11.94	White. Yellow bills and legs, with white nails and claws.
" "	2	" " ..	10.00	8.81	
" "	2	" " ..	11.50	10.81	
Feb. 16.	2	" " ..	14.75	13.44	
" "	2	" " ..	12.63	11.69	
		Average	12.20	11.33	
Feb. 16.	3	Embden–Toulouse.	17.13	16.13	Pied. Yellow or orange bills and legs, with white nails and claws.
" "	3	" "	14.13	13.38	
		Average	15.63	14.75	
Dec. 28.	4	African–Toulouse. .. .	16.00	14.06	All dark birds. Bills yellow or mottled, with black or mottled nails. Yellow legs, with black claws in all but one case, when the claws were white.
" "	4	" "	12.50	11.50	
" "	4	" "	13.50	12.81	
" "	4	" "	14.00	12.63	
" "	4	" "	15.50	14.81	
Feb. 16.	4	" "	15.50	14.50	
" "	4	" "	18.81	17.88	
		Average	15.11	14.02	
Dec. 28.	5	Brown China–African...	10.00	9.13	Partake strongly of the Brown China type. Bills, nails, legs and claws black.
Feb. 16.	5	" " ...	12.13	11.25	
" "	5	" " ...	11.50	10.75	
		Average	11.21	10.37	

[1] February, 1897. [2] December, 1896.

TABLE XXI.—*Continued.*

Date.	Yard No.	Mating.	Live weight. Pounds.	Dressed weight. Pounds.	Notes on Color, Etc.
Dec. 28.[2]	6	Br. China-Br. China . .	9.50	8.38	Pure Brown China. Pick hard.
" "	6	" "	9.00	8 00	
" "	6	" "	15.50	14 25	
		Average	11.33	10.21	
Dec. 28.	8	African-Embden.......	13 00	12.19	One African type, two pied. Mottled or yellow bills, black nails, yellow legs, and black claws. One, claws partly white.
Feb. 16.[1]	8	" "	19.38	18.13	
" "	8	" "	15.50	15.00	
		Average	15.96	15.10	
Dec. 28.	9	Brown China-Embden	13.25	12.25	Pied. Yellow bills and legs, with white nails and claws.
Feb. 16	9	" " ..	14.88	13.19	
" "	9	" " ..	11.63	11.13	
		Average	13.08	12.19	
Dec. 28.	11	Toulouse-Brown China..	12.25	11.38	All dark, but only one showed decided Brown China type. One, black bill, others mottled, one yellow, black nails, Yellow legs, with black claws. Skin tender.
" "	11	" " ..	11.50	10.63	
" "	11	" " ..	13.75	13.00	
" "	11	" " ..	10.50	10.00	
" "	11	" " ..	9.25	8.75	
Feb. 16.	11	" " ..	14.25	13.44	
" "	11	" " .	13.50	12.56	
		Average	12.14	11.39	
Dec. 28.[2]	12	African-Brown China...	11.25	10.63	All dark in color. Black bills and nails, legs yellow, with black claws.
" "	12	" " ...	10.00	9.00	
" "	12	" " ...	10.00	8.75	
" "	12	" " ...	11.00	10.06	
" "	12	" " ...	10.50	9.31	
Feb. 16.[1]	12	" " ...	12.88	11.88	
" "	12	" " ...	12.00	11.19	
		Average	11.09	10.11	

[1] February, 1897. [2] December, 1896.

TABLE XXI.—*Continued.*

Date.	Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	NOTES ON COLOR, ETC.
Dec. 28.	13	White China-Embden.	10.25	8.81	Pied. One quite dark in color. Yellow or mottled bills, with black nails. Yellow legs, white claws, one with black claws, and one with five white and three black claws. (This cross shows impure or mixed blood in the parent stock.)
" "	13	" " .	10.50	9.00	
" "	13	" " ...	9.50	8.68	
Feb. 16.	13	" " ...	11.13	10.81	
" "	13	" " ...	12.38	11.13	
		Average	10.75	9.57	
Dec. 28.	14	Brown China-Toulouse..	13.75	12.19	All dark birds. Yellow or mottled bills and black nails. Yellow legs, with black claws.
" "	14	" " ..	13.75	12.44	
" "	14	" " ..	13.25	12.38	
" "	14	" " ..	13.50	12.00	
" "	14	" " ..	14.50	13.38	
Feb. 16.	14	" " ..	15.06	14.19	
" "	14	" " ..	19.38	18 38	
		Average	14.74	13.57	
Dec. 28.	15	Embden-African........	15.25	13.75	Pied. Yellow bills and legs, white or mottled nails, and white claws.
Feb. 16.	15	" "	18.50	17.63	
" "	15	" "	18.56	17.75	
		Average	17.43	16.37	
Dec. 28.	17	African-African	15.50	14.19	Pure Africans.
" "	17	" "	12.25	11.63	
		Average	13 87	12.91	
Dec. 28.	20	Toulouse-WhiteChina ..	13.00	11.44	White. Yellow bill and legs, white nail and claws.

In table XX the largest average weight was reached by yard 14, Brown China-Toulouse cross. The heaviest bird, weighed alive, 17.94 pounds, and the average of twelve birds was 16.06 pounds live weight, and 15.32 pounds dressed weight. The opposite mating—a Toulouse gander with Brown China females—

produced goslings which at this time only averaged 11.81 pounds alive, and 11.03 pounds each dressed. (Yard No. 11.)

The second heaviest average weight was made by the African-Toulouse cross, in yard 4, which weighed 15.22 pounds alive, and the opposite mating—yard 1, Toulouse-African—averaged 15.19 pounds each, making the averages almost identical. The African-Embden cross, yard 8, was third in average live weight, 15.06 pounds, and the opposite mating, yard 15, Embden-African, averaged 14.16 pounds.

The smallest birds were from yard 12, African-Brown China cross, which averaged, alive, only 10.72 pounds. The opposite mating, yard 5, averaged 11.50 pounds each. The No. 12 goslings were quite uniform in size, but those from yard 5 ranged from 9.88 to 14.06 pounds each.

Table XXI shows the weights of young geese dressed the very last of December, and in February. In this table, the Embden-African cross, No. 15, reached the greatest average weight—17.43 pounds alive, and 16.37 pounds dressed. The opposite mating, No. 8, African-Embden cross, averaged 15.96 pounds alive. One, No. 8, weighed, alive, 19.38 pounds. One, No. 14, Brown China-Toulouse, reached the same weight, but the average was only 14.74 pounds live weight. Toulouse-Brown China, No. 11, only averaged 12.14 pounds. As in table XX, yards 1 and 4 averaged nearly alike. Yard 1, Toulouse-African, weighed 15.81 pounds each, alive, and yard 4, the opposite mating, averaged 15.11 pounds.

Yard No. 3, Embden-Toulouse cross, averaged, alive, 15.63 pounds, and should be classed with the best breeds.

The birds from yard No. 12, African-Brown China cross, averaged but little more than those in table XX, viz., 11.09 pounds each, but they slightly exceeded in average weight those from yard 13, White China-Embden, which reached only 10.75 pounds, and therefore made the lowest average. The average weights of the birds from each yard are found by using the figures in tables XX and XXI, to be as follows:

TABLE XXII.—*Showing Average Live and Dressed Weights of all the Geese in Tables XX and XXI.*

YARD.	MATING.	No. of geese.	Average live weight in pounds.	Average dressed weight in pounds.
15	Embden-African	6	15.80	14.83
8	African-Embden	7	15.45	14.50
1	Toulouse-African	4	15.50	14.91
4	African-Toulouse	9	15.14	14.14
14	Brown China-Toulouse	19	15.58	14.68
11	Toulouse-Brown China	9	12.07	11.31
5	Brown China-African	6	11.35	10.78
12	African-Brown China	14	10.91	10.18
9	Brown China-Embden	6	12.99	12.34
2	Embden-Brown China	8	12.38	11.47
10	Embden-White China	1	11.69	11.13
13	White China-Embden	8	10.98	9.98
3	Embden-Toulouse	9	14.68	13.89
20	Toulouse-White China	1	13.00	11.44
6	Brown China-Brown China	3	11.33	10.21
17	African-African	2	13.87	12.91

While there is comparatively little difference between the Embden-African and the Toulouse-African crosses in regard to the size attained, the former is very certain to produce goslings with a good deal of white upon them, and that insures yellow bills and legs, generally easy picking, and a handsome appearance when dressed. An Embden-African crossbred bird is generally good looking and quick selling.

It will be noticed from the figures in table XXII that the *size* of the *female* most frequently influences the size of the offspring. This is most noticeable in the case of the Brown China-Toulouse cross, and the opposite mating—yards 14 and 11—where the offspring of the Toulouse females averaged 3.51 pounds live weight more than the offspring of the Brown China females, although practically of the same blood. This was true in a less marked degree in the case of the Brown China-African cross, yards 5 and 12, and the Brown China-Embden cross, yards 9 and 2. It serves to show the importance of good sized, well developed *females* in breeding geese.

EXPERIMENTS WITH GEESE IN 1897.

The goose breeding experiments in the spring and summer of 1897 were considerably interrupted by the renewal of the work at the quarry early in the season, and the removal of the poultry buildings to a new site a little later on. The necessity of having all incubation done at some distance from the quarry, owing to the jar produced by blasting, caused some inconvenience and delay, and hatching was less successful than we had hoped it would be. The majority of the breeding stock was the same as used the year before. The few exceptions were some young Africans and Embdens, the former reserved from the hatch of the previous year, and the latter purchased from a breeder in Maine. Some changes in mating were made necessary on account of the losses in the attack by dogs, and the death of the pure Embden gander in pen No. 15, which had produced the Embden-African

crossbred birds taking first rank for size and rapidity of growth. A new mating to secure pure Toulouse goslings was made, and two pens were given to the crossing of the White and Brown China geese. The yards and matings for 1897 were as follows:

Matings, Season of 1897.

Yard No. 1	Embden	gander and	3 African geese.
" " 15	"	" "	1 " goose
" " 2	"	" "	1 Brown China goose.
" " 3	"	" "	2 Toulouse geese.
" " 4	White China	" "	2 Brown China "
" " 5	Brown China	" "	2 African "
" " 6	Embden	" "	2 Embden "
" " 19	"	" "	2 " "
" " 7	Toulouse	" "	2 " "
" " 8	African	" "	3 " "
" " 9	Brown China	" "	2 " "
" " 10	Embden	" "	2 White China "
" " 11	African	" "	2 " "
" " 13	White China	" "	1 Embden goose.
" " 14	Brown China	" "	2 Toulouse geese.
" " 16	" "	" "	2 White China "
" " 17	African	" "	2 African "
" " 18	Toulouse	" "	2 Toulouse "
" " 20	"	" "	1 White China goose.
" " 21	White China	" "	2 Toulouse geese.

Early in January all the geese were weighed. They were in good store condition, not at all fat, and feeding for laying had not commenced. The weights are given below:

TABLE XXIII.—*Live Weights of Breeding Geese.—January 1897.*

Breed.	Yard No.	Band No.	Age.	Weights. Lbs.	Weights. Oz.	Average Weight. Lbs.	Average Weight. Oz.
African, Male	8	246	2 years+[1]	13	13		
" "	11	385	Young	13	2		
" "	17	224	2 years+	16	2		
3 Males				43	1	14	5⅔
African, Female	1	397	Young	10	8		
		362	"	14	8		
		386	2 years+	11	15		
" "	5	384	2 " +	12	9		
		232	2 " +	12	3		
" "	15	374	Young	14	12		
" "	17	363	2 years+	13	2		
		223	2 " +	10	14		
8 Females				100	7	12	8⅞
Toulouse, Male	7	242	2 years+	13	9		
" "	18	281	2 " +	11	11		
" "	20	379	2 " +	14	4		
3 Males				39	8	13	2⅔
Toulouse, Female	3	215	2 years+	10	5		
		203	2 " +	10	7		
" "	14	380	2 " +	11	12		
		352	2 " +	8	11		
" "	18	216	2 " +	10	5		
		202	2 " +	11	0		
" "	21	289	2 " +	11	9		
		326	2 " +	10	15		
8 Females				85	0	10	10
Embden, Male	1	309	Young	10	1		
" "	2	378	2 years	14	8		
" "	3	357	2 "	13	4		
" "	6	256	2 " +	11	0		
" "	10	337	Young	9	12		
" "	15	335	2 years	15	10		
" "	19	264	2 " +	12	0		
7 Males				86	3	12	5
Embden, Female	6	334	2 years	13	6		
		360	Young	11	14		
" "	7	338	2 years	12	0		
		398	2 "	11	2		
" "	8	389	2 "	12	1		
		244	2 " +	9	13		
		247	2 " +	9	14		
" "	9	12	2 " +	8	2		
		378	2 " +	9	13		
" "	13	356	Young	10	4		
" "	19	225	2 years+	11	4		
		226	2 " +	11	3		
12 Females				130	12	10	14⅓

[1] More than two years old.

TABLE XXIII.—*Continued.*

BREED.	Yard No.	Band No.	AGE.	WEIGHTS. Lbs.	WEIGHTS. Oz.	AVERAGE WEIGHT. Lbs.	AVERAGE WEIGHT. Oz.
Brown China, Male............	5	383	2 years+[1].	11	2	....	....
" "	9	278	2 " +..	11	8	....	....
" "	14	396	2 " +..	10	8	....	....
" "	16	253	2 " +..	8	8	....	....
4 Males....................	....	....	....	41	10	10	6½
Brown China, Female.........	4	322	2 years+..	8	11	....	....
		235	2 " +..	7	5	....	....
" "	2	361	2 " +..	11	12	....	....
3 Females..................	....	....	....	27	12	9	4
White China, Male............	4	265	2 years+..	7	15	....	....
" "	13	245	2 " +..	10	7	....	....
" "	21	309	2 " +..	9	0	....	....
3 Males....................	....	....	....	27	6	9	2
White China, Female....	10	228	2 years+..	6	5	....	....
		277	2 " +..	6	2	....	....
" "	11	1	2 " +..	8	0	....	....
		308	Young....	8	10	....	....
" "	16	243	2 years+..	6	10	....	....
		367	Young....	9	7	....	....
" "	20	290	2 years+..	8	13	....	....
7 Females..................	....	....	....	53	15	7	11 2/7

African ganders and geese averaged more in weight than any other breed. The ganders weighed 14.35 pounds each, and the geese 12.55 pounds. The heaviest gander weighed 16.13 pounds, and the heaviest goose 14.75 pounds. These weights exceeded those of individuals from any other breed.

Toulouse ganders take the next place in the table with an average weight of 13.17 pounds, but that weight would be exceeded by the average of the Embden ganders if the two young birds were excluded. The average weight of the five Embden ganders, over two years old, is 13.28 pounds. The Embden geese also ex-

[1] More than two years old.

ceeded the Toulouse in average weight, as the former weighed 10.90 pounds, and the latter 10.63 pounds each. Two Embden ganders and four Embden geese exceeded in individual weights those of the heaviest Toulouse birds. Four Embden females, two in yard No. 8, and two in yard No. 9, were originally purchased from poultry men in Ohio and Missouri, and have never reached the weights which well developed Embdens should attain. They were used in these experiments only because of inability to secure larger stock.

The White China females averaged only 7.71 pounds each, and the ganders weighed 9.13 pounds each—about two ounces less than the average weight of the Brown China *females*, which equaled 9.25 pounds. The Brown China ganders averaged 10.41 pounds. These weights will appear to many to be much below the standard weights for the different breeds, which is quite true. Some of these birds would hardly reach standard weights, even when very fat and fitted for exhibition, while others would doubtless reach standard weight. In securing the original stock for the experiments no effort was made to secure *prize stock*, because birds forced to show condition are seldom reliable breeders; but the best breeding stock possible to obtain was secured. In a few instances stock obtained from distant points proved inferior in quality, and, whenever possible to obtain better stock, a change was made. Toulouse geese can be more easily obtained than other varieties. Fine Embdens or Africans are more difficult to secure, and any one desiring to purchase should place an order for the stock in May or June, so that the goslings can be reserved when the young are sold off as green geese. One thereby obtains the choice birds of the flock for breeding stock.

The same system of management was followed as in 1896, with the exception that no cabbage was fed in the early spring, potatoes, beets, and turnips supplying the demand for a bulky green food until grass began to grow. The roots were fed both raw and cooked, but generally cooked, and mixed with bran, meal, and scraps, into dough, which was fed every other morning; whole oats

were fed on the alternate mornings, and whole grain, consisting of equal parts of corn and oats, was fed every night. An abundant supply of gravel and crushed oyster shells was kept in the pens at all times. Water was supplied in pools or tubs through the season. Barrels were used for nests, and the same method of marking the eggs, and, later on, of marking the goslings was adopted as used the previous season.

EGG PRODUCTION.

The first egg laid was produced by a young White China goose, in pen No. 16, on January 12th, and by the end of the month she had laid 7 eggs. The only other goose to lay in January was an African, in pen No. 1, which laid one egg on the 22d. Representatives of all the breeds were laying in February, although only one Toulouse egg was laid before March 1st. Table XXIV shows the egg yields by months, and the average of each breed for the season.

TABLE XXIV.—*Showing Record of Goose Eggs Laid in 1897.*

Yard No.	Mating. Male.	Mating. Female.	No. of females.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.	Average.
6	Embden,	Embden.....	2	...	1	20	21	4	...	46	23.0
7	Toulouse,	Embden.....	2	...	...	8	7	...	...	15	7.5
8	African,	Embden.....	3	...	2	26	21	16	...	65	21.6
9	Brown China,	Embden.....	2	...	...	13	23	...	...	36	18.0
13	White China,	Embden.....	1	...	...	3	9	...	...	12	12.0
19	Embden,	Embden.....	2	...	5	20	11	10	...	46	23.0
	Totals................		12	...	8	90	92	30	...	220	18.3
1	Embden,	African.....	3	1	5	25	18	2	1	52	17.3
5	Brown China,	African	2	...	...	9	7	5	...	21	10.5
15	Embden,	African	1	...	3	19	8	...	...	30	30.0
17	African,	African... ..	3	..	2	25	18	2	...	47	15.6
	Totals........... ...		9	1	10	78	51	9	1	150	16.6
3	Embden,	Toulouse	2	...	...	24	22	15	1	62	31.0
14	Brown China,	Toulouse	2	...	..	20	11	8	...	39	19.5
18	Toulouse,	Toulouse	2	...	1	25	10	9	...	45	22.5
21	White China,	Toulouse	2	...	...	24	14	7	...	45	22.5
	Totals......		8	...	1	93	57	39	1	191	23.8
2	Embden,	Brown China.	1	....	3	16	10	6	...	35	35.0
4	White China,	Brown China.	2	...	...	18	17	13	3	51	25.5
	Totals...............		3	...	3	34	27	19	3	86	28.6
10	Embden,	White China.	2	...	4	21	20	22	5	72	36.0
11	African,	White China.	2*	...	...	18	25	20	1	64	32.0
16	Brown China,	White China.	2	7	6	10	19	7	...	49	24.5
20	Toulouse,	White China.	1	...	...	15	11	14	...	40	40.0
	Totals........... ..		7	7	10	64	75	63	6	225	32.1

* One goose, in No. 11, laid deformed eggs.

The average number of eggs laid by the different breeds during March was as follows: Toulouse, 11.62 eggs; Brown China, 11.33 eggs; White China, 9.14 eggs; African, 8.66 eggs; and Embden, 7.50 eggs.

The average number laid in April we find to be: White China, 10.50 eggs; Brown China, 9.00 eggs; Embden, 7.66 eggs; Toulouse, 7.12 eggs; and African, 5.66 eggs.

In May the average number laid was as follows: White China, 9.00 eggs; Brown China, 6.33 eggs; Toulouse, 4.87 eggs; Embden, 2.50 eggs; and African, 1.00 egg. Very few eggs were produced after June 1st. The Embdens laid none, and the Africans and Toulouse laid but one egg respectively, while the Brown and White China females lacked but one egg of averaging one each. The total number of eggs laid by 39 females was 872, equal to an average of 22.35 eggs each, a trifle less than the average in 1896, which was 23.58 eggs for the females of all the breeds. The average made by the Embden females was considerably reduced by the small number of eggs laid by the geese in pen No. 7. If this pen be left out the average egg production would be 20.5 eggs. The same two geese in No. 7 only averaged 11 eggs each in 1896. Table XXV gives a summary of the egg yields for the two years.

TABLE XXV.—*Summary of Goose Eggs Laid in 1896 and 1897.*

BREED.	Year.	No. of females.	Total Eggs Laid in						Total.	Average.
			Jan.	Feb.	Mar.	Apr.	May.	June.		
Embden..	1896	11	...	5	79	66	52	6	208	18.9
"	1897	12	...	8	90	92	30	..	220	18.3
Totals and average for two years..........	......	23	...	13	169	158	82	6	428	18.6
African	1896	9	...	3	70	46	28	...	147	16.3
"	1897	9	1	10	78	51	9	1	150	16.6
Totals and average for two years....................	......	18	1	13	148	97	37	1	297	16.5
Toulouse..................	1896	8	...	...	80	87	57	1	225	28.1
"	1897	8	...	1	93	57	39	1	191	23.8
Totals and average for two years...	.....	16	...	1	173	144	96	2	416	26.0
Brown China..............	1896	7	...	10	60	76	64	14	224	32.0
"	1897	3	...	3	34	27	19	3	86	28.6
Totals and average for two years.....	......	10	...	13	94	103	83	17	310	31.0
White China...............	1896	5	2	5	37	44	51	19	158	31.6
"	1897	7	7	10	64	75	63	6	225	32.1
Totals and average for two years........	......	12	9	15	101	119	114	25	383	31.9

The Africans and White Chinas increased their average egg yield a fraction of an egg, while the Embdens allowed theirs to decrease as much. The Brown China egg yield fell off 3.4 eggs, and the Toulouse 4.3 eggs, in average yield, as compared with the results in 1896. The changes give the first place for egg production, taking the results of the two years together, to the White Chinas, with an average of 31.9 eggs; then Brown Chinas, 31.6 eggs; Toulouse, 26.0 eggs; Embdens, 18.6 eggs; and Africans, 16.5 eggs. The largest individual egg yields in 1897 were as follows: One White China goose, in pen 20, laid 40 eggs; a Brown China goose, in pen 2, laid 35 eggs; two Toulouse females, in pen 3, averaged 31 eggs each; an African, in pen 15, laid 30 eggs; and four Embden females, in pens 6 and 19, averaged 23 eggs each. A careful weeding out of poor layers for a series of years would make a material change in the average egg production of the flock.

WEIGHTS OF GOOSE EGGS.

When the number of eggs on hand was sufficient to make it possible, five eggs from each mating were carefully weighed on two different occasions, March 18th and 29th, and a record of the weights made for comparison with those obtained in 1896. The weights are given in table XXVI, which is so arranged as to bring the females of each breed together.

TABLE XXVI.—*Showing Record of Weights of Eggs Laid by Geese in 1897.*

Yard. No.	Mating. Males.	Mating. Females.	No. of females.	No. of eggs weighed.	Total weight in ounces.	Average weight in ounces.	Weight of largest egg in ounces.	Weight of smallest egg in ounces.
6	Embden,	Embden . ..	2	5	34	6.8	9.41	5.78
7	Toulouse,	Embden	2	8	55	6.875	7.70	6.27
8	African,	Embden	3	10	63	6.3	7.22	6.02
9	Brown China,	Embden	2	9	60	6.666	6.94	6.10
19	Embden,	Embden	2	10	66	6.6	7.67	6.11
	Totals......		11	42	278	Total average...		6.619
1	Embden,	African......	3	10	59	5.9	7.75	4.97
5	Brown China,	African......	2	7*	61	8.714	11.25	6.88
15	Embden,	African......	1	10	68	6.8	8.80	5.66
17	African,	African	3	10	66	6.6	7.25	5.45
	Totals.................		9	37	254	Total average...		6.864
3	Embden,	Toulouse	2	10	66	6.6	7.05	6.04
14	Brown China,	Toulouse ..	2	10	64	6.4	6.80	5.93
18	Toulouse,	Toulouse ...	2	10	64	6.4	6.90	5.96
21	White China,	Toulouse	2	10	65	6.5	7.50	6.11
	Totals.........		8	40	259	Total average...		6.475
2	Embden,	Brown China.	1	10	60	6.0	6.51	5.41
4	White China,	Brown China.	2	10	48	4.8	5.84	4.84
	Totals.. ,......		3	20	108	Total average...		5.400
10	Embden,	White China.	2	10	52	5.2	6.56	4.71
11	African,	White China.	2	9	49	5.444	6.80	4.76
16	Brown China,	White China.	2	5	23	4.6	5.47	4.16
20	Toulouse,	White China.	1	10	61	6.1	6.27	5.76
	Totals.................		7	34	185	Total average...		5 411

* Included one unusually large egg.

TABLE XXVII.—*Summary of Weights of Goose Eggs Laid in 1896 and 1897.*

BREED.	Year.	No. of females.	No. of eggs weighed.	Total weight in ounces.	Average weight in ounces.
Embden	1896	11	194	1,272	6 556
"	1897	9	42	278	6.619
Totals and average for two years	......	......	236	1,550	6.567
African	1896	8	136	905	6.654
"	1897	9	37	254	6.864
Totals and average for two years	......	......	173	1,159	6.699
Toulouse	1896	8	210	1,314	6.257
"	1897	8	40	259	6.475
Totals and average for two years	......	......	250	1,575	6.300
Brown China	1896	7	201	1,095.5	5.450
"	1897	3	20	108.0	5.400
Totals and average for two years	......	......	221	1,203.5	5.445
White China	1896	5	121	671	5.545
"	1897	7	34	185	5.441
Totals and average for two years	......	......	155	856	5.523

In table XXVII the weights of eggs obtained in the two years are summarized and the average weight for both seasons obtained. Africans laid the largest eggs, averaging practically 6.7 ounces each. Embdens rank next in order, averaging 6.567 ounces each. The eggs of Toulouse geese averaged 6.3 ounces each; those from White Chinas 5.522 ounces, and those from Brown Chinas were smallest in size, averaging but 5.445 ounces each. These averages are the result of weighing from 155 to 250 eggs in each instance, and fairly represent the difference in size in the eggs from the different breeds. Eggs from African geese would average to weigh 5.025 pounds per dozen, which is 3.1 times the average weight of Rhode Island Red and Plymouth Rock hens' eggs, as determined by weighing ten dozens selected for hatching. (Average weight 1.62 pounds.)

LOSS OF WEIGHT IN GOOSE EGGS DURING INCUBATION.

Early in June, eggs from as many different yards as possible were individually weighed, using scales which gave accurate weights to the one hundred twenty-eighth part of an ounce; and after the eggs were numbered in consecutive order, as weighed, they were placed in an incubator for hatching. After being in the incubator seven days they were again weighed. At the end of ten days they were tested by holding in front of a light in the ordinary way, and the clear eggs removed. All showing a germ developed in any degree, were allowed to remain.

At twenty-two days from the beginning of incubation those remaining were again weighed, removed from the incubator and placed under hens. As time for hatching approached, the hens were visited several times at short intervals, so that the weights of the goslings might be obtained as soon as hatched. Unfortunately only three goslings were obtained from the 21 eggs, the germs in the other fertile eggs having apparently been too weak to fully develop, and of the three hatched only one was reared. All the weights are given in table XXVIII.

TABLE XXVIII.—*Showing Weights of Goose Eggs Before and During Incubation, and Weights of Goslings Hatched.*

No. of egg.	Yard No.	MATING.	Weight June 3. Ounces.	Weight June 12. Ounces.	Result of test.	Weight June 25. Ounces.	Weight of goslings hatched. Ounces.	Date when hatched.
1	4	Wh. Ch., Br. Ch..	4.9062	4.5078	Fertile...	4.1093	....	....
2	11	Afr., Wh. Ch.....	5.3281	4.9531	"	4.5547	....	....
3	14	Br. Ch., Tou......	6.3753	6.0000	"	5.6093	....	....
4	14	" "	6.3675	6.0318	"	5.6953	4.3848	July 3.
5	8	Emb., Tou	5.6828	5.3753	"	5.0625	....	....
6	8	" "	5.7500	5.4531	"	5.1250	3.5781	July 4.*
7	3	" "	5.8984	5.5703	"	5.1562	3.7109	July 3.
8	3	" "	5.0547	4.5000	Infertile..	....	....	....
9	10	Emb., Wh. Ch....	5.3753	4.9843	Fertile...	4.6562	....	....
10	10	" "	4.9765	4.6484	Infertile..	....	....	....
11	10	" "	5.2784	4.7578	"	....	....	....
12	10	" " ...	5.1718	4.7656	"	....	....	....
13	10	" "	4.6172	4.1875	"	....	....	....
14	10	" "	4.5987	4.2969	"	....	....	....
15	16	Br. Ch., Wh. Ch..	4.9609	4.6562	Fertile...	4.3359	....	....
16	20	Tou., Wh. Ch ...	5.6875	5.2969	Infertile..	....	....	....
17	4	Wh. Ch., Br. Ch..	5.2187	4.8750	"	....	....	....
18	1	Emb., Afr.......	5.1875	4.8594	"	....	....	....
19	11	Afr., Wh. Ch. ..	5.2265	4.9843	Fertile...	4.7656	....	....
20	4	Wh. Ch., Br. Ch..	5.1015	4.7422	"	4.3750	....	....
21	11	Afr., Wh. Ch....	5.1562	4.8672	"	....	....	....

* Killed by the hen in the nest.

The average weight of the three eggs from which goslings were hatched was 6.0053 ounces at the beginning of incubation, and the average weight of the goslings when hatched was 3.8913 ounces, showing an average loss of 2.1140 ounces during incubation. The individual losses were as follows:

Egg No. 4 lost in hatching	1.9827 ounces.
" " 6 " " "	2.1719 "
" " 7 " " "	2.1875 "

The gosling from egg number four was the only vigorous one, but whether the smaller amount of evaporation from that egg had any relation to the vigor of the gosling we cannot say.

Between the weighings of June 3d and June 12th the average losses were as follows:

Average loss of 12 fertile eggs	0.3369 ounces.
" " " 9 infertile eggs tested out	0.3437 "
" " " 3 fertile eggs which hatched goslings	0.3204 "
" " " 9 fertile eggs which did not hatch	0.3425 "

INCUBATION.

Some of the goose eggs were placed in incubators until time for testing them, when, as a rule, all the fertile eggs were placed under hens, each hen having only eggs from one yard, so that the goslings could be accurately identified, and be marked by punching a hole in the web of the foot. The goslings were taken away from the hens and placed in a "Peep o' Day" brooder soon after hatching, and removed where they could easily resort to one so long as they required artificial heat.

TABLE XXIX.—*Showing the Relative Fertility of Eggs Produced by the Different Matings of Geese in 1897.*

YARD NO.	MATINGS.	TOTAL NO. OF EGGS. Laid.	Set.	Tested out.	Per cent. of eggs tested out from eggs set.	Total No. of goslings hatched.	Per cent. of goslings to eggs set.
	Embden Females.						
6 & 19	Embden- Embden	92	85	14	16.47	46	54.11
7	Toulouse- "	15	15	......	....	7	46.66
8	African- " ...	65	62	17	27.41	12	19.35
9	Brown China- "	36	28	18	64.28	2	7.14
13	White China- "	12	12	1	8.33	3	25.00
		220	202	50	24.75	70	34.65
	Embden Males.						
1 & 15	Embden-African..........	82	75	37	49.33	21	28.00
2	" Brown China.....	35	32	9	28.12	13	46.62
3	" Toulouse	62	50	15	30.00	11	22.00
6 & 19	" Embden........ ..	92	85	14	16.47	46	54.11
10	" White China. ..	72	58	29	50.00	6	10.34
		343	300	104	34.66	97	32.33
	African Females.						
1 & 15	Embden- African. ...	82	75	37	49.33	21	28.00
5	Brown China- "	21	16	5	31 25	3	18.75
17	African- "	47	45	9	20.00	10	22.22
		150	136	51	37.50	34	25.00
	African Males.						
8	African-Embden.........	65	62	17	27 41	12	19.35
11	" White China......	64	30	13	43.33	13	43.33
17	" African...........	47	45	9	20.00	10	22.22
		176	137	39	28.46	35	25.54
	Toulouse Females.						
3	Embden- Toulouse....	62	50	15	30.00	11	22.00
14	Brown China- "	39	36	6	16.66	9	25.00
18	Toulouse- " .. .	45	35	9	25.71	14	40.00
21	White China- " ...	45	34	34	100.00	.....	......
		191	155	64	41.29	34	21.93
	Toulouse Males.						
7	Toulouse-Embden	15	15	.....	. ..	7	46.66
18	" Toulouse.......	45	35	9	25.71	14	40.00
20	" White China ..	40	31	18	58.06	5	16.12
		100	81	27	33.33	26	32.09

TABLE XXIX.—*Continued.*

Yard No.	Mating.	Total No. of Eggs. Laid.	Set.	Tested out.	Per cent. of eggs tested out from eggs set.	Total No. of goslings hatched.	Per cent. of goslings to eggs set.
	Brown China Females.						
2	Embden- Brown China.	35	32	9	28.12	13	46.62
4	White China- " .	51	40	19	47.50	5	12.50
		86	72	28	38.88	18	25.00
	Brown China Males.						
5	Brown China-African.....	21	16	5	31.25	3	18.75
9	" " Embden.. ..	36	28	18	64.28	2	7.14
14	" " Toulouse....	39	36	6	16.66	9	25.00
16	" " White China.	49	28	7	25.00	3	10.71
		145	108	36	33.33	17	15.74
	White China Females.						
10	Embden- White China..	72	58	29	50.00	6	10.34
11	African- " "	64	30	13	43.33	13	43.33
16	Brown China- " "	49	28	7	25.00	3	10.71
20	Toulouse- " "	40	31	18	58.06	5	16.12
		225	147	67	45.57	27	18.36
	White China Males.						
4	White China-Brown China.	51	40	19	47.50	5	12.50
13	" Embden.....	12	12	1	8.33	3	25.00
21	" Toulouse ...	45	34	34	100.00	......	....
		108	86	54	62.79	8	9.30

In the above table is shown the number of eggs laid by each mating, the number set, how many were tested out as infertile, and the number of goslings hatched in each case. The figures for each mating appear twice in the table—once in obtaining the per cents. for the *females* of each breed, and once in calculating the per cents. for the *males.* The total number of eggs set was 712, of which 260 were tested out as infertile, and from the remainder 183 goslings were hatched. The two columns of per cents.—eggs tested and goslings hatched—are both calculated in relation to the total number of *eggs set* in each case. It is the custom of most poultrymen to calculate the per cent. of their

hatches from the *number* of *fertile eggs* which remain after the operation of testing out those which are infertile, which is perfectly proper if the efficiency of an incubator or the relative success of the process of *incubation* is to be determined; but in this case we wish to find out whether any difference in the *fertility* of the eggs produced by different matings can be fairly attributed to the influence of different breeds or matings. A sufficient degree of vitality to hatch vigorous goslings from as many of the eggs set as possible is the end sought; therefore the number of *goslings hatched* is compared with the number of *eggs set*, conditions of incubation having been made as nearly as possible alike for all.

Of necessity these per cents. are much lower than would be the case if the goslings hatched had been compared with the *fertile* eggs only, as, for instance, in pen 11, where 43.33 per cent. of the *eggs set* hatched goslings, the number hatched equaled 76.47 per cent. of the *fertile eggs*. In the same way pens 6 and 19 hatched 64.78 per cent. of the *fertile eggs*, but only 54.11 per cent. of the *eggs set*.

Pen 21, a White China gander with Toulouse geese, did not produce a single *fertile egg* from the 34 set, and consequently 100 per cent. were tested out. The next highest per cent. tested out was from pen 9—Brown China-Embden—64.28 per cent. The Toulouse-Embden mating, in pen 7, produced but 15 eggs, but none were tested out as infertile, and the next lowest per cent. of infertile eggs was from pen 13—White China-Embden—in which case one egg was tested out from twelve, the whole number laid by the goose in that pen.

The highest per cent. of goslings hatched from eggs set was in the case of the pure Embden matings, in pens 6 and 19, and was 54.11 per cent.; and the next two in rank were pen 7, Toulouse-Embden, 46.66 per cent.; and pen 2, Embden-Brown China, 46.62 per cent. The pure Toulouse mating, pen 18, hatched 40 per cent. of the eggs set, and the pure African, pen 17, only 22.22 per cent. In the pure African mating for 1896, 51.21 per cent. of the eggs set were hatched. As before stated, no goslings

were hatched from pen 21, White China-Toulouse mating. Pen 9, Brown China-Embden, hatched but 7.14 per cent.; and pen 10, Embden-White China, only 10.34 per cent. of eggs set. Pen number 16, Brown China-White China, and the opposite mating, White China-Brown China, in pen 4, hatched but 10.71 and 12.50 per cent. respectively. In the table, the females and males of each breed are grouped separately, and the per cents. found for the total number of individuals in each case, and in table XXX these per cents. are brought together and the average for each breed calculated.

TABLE XXX.—*Showing Average Per Cents. of Eggs Tested Out and Goslings Hatched from Eggs Set in 1897.*[1]

BREED.	SEX.	Per cent. of eggs tested out from eggs set.	Average.	Per cent. of goslings hatched from eggs set.	Average.
Embden	Females	24.75	29.70	34.65	33.49
	Males	34.66		32.33	
Toulouse	Females	41.29	37.81	29.93	31.01
	Males	33.33		32.09	
African	Females	37.50	32.98	25.00	25.27
	Males	28.46		25.54	
Brown China	Females	38.88	36.10	25.00	20.37
	Males	33.33		15.74	
White China	Females	45.57	54.18	18.36	13.83
	Males	62.79		9.30	

The per cent. of goslings hatched is low in all cases; much lower than is usually secured by practical goose breeders, where the breeding stock has liberty and the eggs are set about as soon as laid. In these experiments the percentages are considerably

[1] Compare with table V for 1896.

reduced by the poor success of the White China matings, which the practical breeder should avoid. By turning to table V, the reader will see that the percentages are considerably lower in the case of Africans and Brown Chinas than in 1896, while in the case of Embdens and White Chinas they are a little higher. The White Chinas made a very poor record, and take the lowest place, as was the case in 1896. In table XXXI we have summarized the data regarding the fertility of eggs for the two seasons, and find that the Africans, as a breed, both males and females, have given the highest per cent. of goslings from eggs set, the average for the breed being 38.09 per cent. This breed also shows the lowest per cent. of infertile eggs—32.18 per cent. Toulouse rank second, Embdens, third, Brown China, fourth, with a per cent. of 28.57, and White China last with a hatch of 10.8 per cent. of the eggs set.

TABLE XXXI.—*Summary of the Per Cents. of Eggs Tested Out and Goslings Hatched in 1896 and 1897.*

BREED.	Sex.	Year.	Per cent. of eggs tested out from eggs set.	Average	Average of both sexes.	Per cent. of goslings hatched from eggs set.	Average	Average of both sexes.
African......	Females .	1896	34.53	36.01	32.18	47.48	36.24	38.09
		1897	37.50			25.00		
	Males....	1896	28.26	28.36		54.34	39.94	
		1897	28.46			25.54		
Toulouse.....	Females .	1896	41.26	41.27	43.32	39.80	34.86	32.22
		1897	41.29			29.93		
	Males....	1896	57.41	45.37		27.09	29.59	
		1897	33.33			32.09		
Embden.....	Females .	1896	49.24	36.99	39.46	24.62	29 63	30.46
		1897	24.75			34.65		
	Males....	1896	49.23	41.94		30.25	31.29	
		1897	34.66			32.33		
Brown China.	Females .	1896	33.33	36.10	35.81	42.42	33.71	28.57
		1897	38.88			25.00		
	Males....	1896	37.71	35.52		31.14	23.44	
		1897	33.33			15.74		
White China.	Females .	1896	86.45	66.01	67.49	3.75	11.05	10.80
		1897	45.57			18.26		
	Males....	1896	75 15	68.79		11 80	10.55	
		1897	62.79			9.30		

GROWTH OF GOSLINGS.

When about 24 hours old the goslings were placed in a brooder and fed and cared for substantially as in 1896, with the exception that they did not have so abundant a variety of green food in July and August as during that season, when they were hurdled in a field of dwarf Essex rape. Their pasturage was mainly a limited area of grass, green oats and rye, with some rape, oats and corn, cut and fed to them in a green condition. They were weighed at approximately five, eight and ten weeks old, and the weights re-recorded for comparison. The earliest goslings were hatched April 2d, and included only pure Embdens and Africans. The next were hatched April 29th, and included representatives from 13 matings. The third lot was hatched May 25th, and represented fifteen matings. The last table includes birds from nine matings hatched at different dates, and the weights taken are compiled in one table.

TABLE XXXII.—*Showing Weights of Goslings Hatched April 2d, 1897.—First Hatch.*

Yard number.	MATINGS.	Weights May 8th. 36 days old.			Weights May 29th. 57 days old.				Weights June 12th. 71 days old.				Average gain in 35 days. Pounds.
		Number of goslings.	Total pounds.	Average pounds.	Number of goslings.	Total pounds.	Average pounds.	Gain in 21 days. Pounds.	Number of goslings.	Total pounds.	Average pounds.	Gain in 14 days. Pounds.	
6 & 19	Embden-Embden	13	23.62	1.81	12	64.25	5.35	3.54	10	86.44	8.64	3.30	6.83
									2[1]	10.06	5.03	....	....
17	African-African	3	6.50	2.16	3	19.00	6.33	4.17	3	29.63	9.87	3.54	7.71

[1] One cripple, and one dwarf.

TABLE XXXIII.—*Showing Weights of Goslings Hatched April 29th, 1897.—Second Hatch.*

YARD NO.	MATING.	WEIGHED JUNE 5, 37 DAYS OLD.			WEIGHED JUNE 25, 57 DAYS OLD.				WEIGHED JULY 10, 72 DAYS OLD.				
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in 20 days. Pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in 15 days. Pounds.	Gain in 35 days. Pounds.
1 & 15	Embden-African..........	6	19.44	3.24	6	42.69	7.11	3.87	6	54.19	9.03	1.92	5.79
2	Embden-Brown China....	7	24.25	3.46	7	49.25	7.03	3.57	7	62.13	8.87	1.84	5.41
3	Embden-Toulouse........	1	4.13	4.13	1	7.88	7.88	3.75	1	9.31	9.31	1.43	5 18
7	Toulouse-Embden........	2	6.44	3.22	2	14.81	7.40	4.18	2	20.06	10.03	2.63	6.81
8	African-Embden.	4	14.13	3.53	3	23.25	7.75	4.22	3	30 50	10.16	2.41	6.63
9	Brown China-Embden....	1	3.38	3.38	1	6.88	6.88	3.50	1	8.44	8 44	1.56	5.06
11	African-White China. ..	3	12.13	4.04	3	22.31	7.43	3.39	3	25.56	8.52	1.09	4.48
13	White China-Embden....	1	3.31	3.31	1	6.88	6.88	3.57	1	8.25	8.25	1.37	4.94
14	Brown China-Toulouse...	4	12.38	3.09	4	27.63	6.90	3.81	4	35.94	8.98	2.08	5.89
17	African-African..	2	8.00	4.00	2	17.88	8.94	4.94	2	22.81	11.40	2.46	7.40
18	Toulouse-Toulouse.......	9	30.69	3.41	8	54.94	6.86	3.45	8	69.31	8.66	1.80	5.25
19 & 6	Embden-Embden.........	6	19.94	3.32	6	43.44	7.24	3.92	6	56.31	9.38	2.14	6.06
20	Toulouse-White China....	1	3.44	3.44	1	7.63	7.63	4.19	1	9.69	9.69	2.06	6.25

TABLE XXXIV.—*Showing Weights of Goslings Hatched May 28th, 1897.—Third Hatch.*

Yard No.	Mating.	Weighed June 30, 36 Days Old.			Weighed July 23, 59 Days Old.				Weighed Aug. 7, 74 Days Old.				
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings	Total pounds.	Average pounds.	Gain in 23 days. Pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in 15 days. Pounds.	Total gain in 38 days. Pounds.
1 & 15	Embden-African.........	11	35.88	3.26	11	86.31	7.84	4.58	11	100.94	9.17	1.33	5.91
2	Embden-Brown China....	2	5.94	2.97	2	15.56	7.78	4.81	2	18 50	9.25	1.47	6.28
3	Embden-Toulouse.......	6	18.50	3.08	5	34.94	6.98	3.90	5	42.75	8.55	1.57	5.47
4	White China-Brown China	3	6.63	2.21	3	17.00	5.66	3.45	3	19.06	6.35	.69	4.14
7	Toulouse-Embden........	4	12.75	3.18	4	31.19	7.79	4.61	4	40.13	10.03	2.24	6.85
8	African-Embden.	5	16.06	3.21	4	30.13	7.53	4.32	4	37.25	9.31	1.78	6.10
10	Embden-White China....	6	17.81	2.97	6	39.38	6.56	3.59	5	42 06	8 41	1.85	5.44
11	African-White China. ...	5	10.81	2.16	5	26.75	5.35	3.19	5	35.44	7.08	1.73	4.92
13	White China-Embden	1	3.38	3.38	1	7.69	7.69	4.31	1	9.25	9.25	1.56	5.87
14	Brown China-Toulouse...	1	1.94	1.94	...	......	......	......	...	......	......	......	......
16	Brown China-White China	1	2.56	2.56	1	6.13	6.13	3.57	1	8.13	8.13	2.00	5.57
17	African-African.........	1	3.25	3.25	1	7.50	7.50	4.25	1	9.00	9.00	1.50	5.75
18	Toulouse-Toulouse.......	3	13.44	4.48	3	25.94	8.64	4.16	3	30.56	10.18	1.54	5.70
19 & 6	Embden-Embden.........	9	35.69	3.96	9	73.44	8.16	4.20	9	85.69	9.52	1.36	5.56
20	Toulouse-White China....	1	3 31	3.31	1	7.25	7.25	3.94	1	9.06	9.06	1.81	5.75

TABLE XXXV.—*Showing Weights of Goslings Hatched at Different Times After June 1st, 1897.*

Yard Number.	Mating.	Weights at 5 Weeks Old.			Weights at 8 Weeks Old.				Weights at 10 Weeks Old.			
		No. of goslings.	Total pounds.	Average pounds.	No. of goslings.	Total pounds.	Average pounds.	Gains in pounds.	No. of goslings.	Total pounds.	Average pounds.	Gain in pounds.
2	Embden-Brown China	....	......	....	1	8.25	8.25	....	1	10.13	10.13	1.88
3	Embden-Toulouse	...	......	....	1	7.56	7.56	....	1	8.38	8.38	.82
4	White China-Brown China	2	10.94	5.47	2	16.00	8.00	2.53	2	16.06	8.03	.03
8	African-Embden	1	5.69	5.69	1	9.69	9.69	4.00	1	10.00	10.00	.31
11	African-White China	4	21.19	5.29	4	25.63	6.40	1.11	4	32.75	8.13	1.73
13	White China-Embden	....	......	....	1	7.50	7.50	....	1	9.44	9.44	1.94
18	Toulouse-Toulouse	1	6.31	6.31	1	9.00	9.00	2.69	1	10.63	10.63	1.63
19 & 6	Embden-Embden	...	......	...	3	26.26	8.75	....	3	31.06	10.35	1.60
20	Toulouse-White China	....	......	....	2	16.06	8.03	....	2	18.69	9.34	1.31

NOTES ON THE TABLES.

The first weighing was made when the goslings were five weeks old, or as near that age as possible, and we will first consider the growth of the goslings in that period of their lives. The goslings in table XXXV are not included in these notes.

First Period of Growth.

First Hatch.—The heaviest gosling at 36 days old was an Embden which weighed 2.75 pounds. The heaviest African in the hatch, at this time, weighed 2.25 pounds. The 13 Embdens, however, averaged but 1.81 pounds, while the 3 Africans averaged 2.16 pounds.

Second Hatch.—The heaviest bird in this hatch at 37 days old was an Embden-Brown China, pen 2, which weighed just 5 pounds. The average of that pen was 3.46 pounds, and was exceeded by 4 other pens: No. 3, Embden-Toulouse, 4.13 pounds; No. 11, African-White China, 4.04 pounds; No. 17, pure Africans, 4 pounds; and No. 8, African-Embden, 35.3 pounds. The greatest average gain per day was 1.785 ounces, by the Embden-Toulouse cross.

Third Hatch.—At 36 days old the pure Toulouse goslings averaged most, weighing 4.48 pounds each. The pure Embdens ranked second, 3.96 pounds each, and the White China-Embden cross, pen 13, stood third at 3.38 pounds. The greatest average daily growth was 1.99 ounces, in the case of the Toulouse goslings. Two pure bred birds, one Embden, and one Toulouse, each weighed 4.94 pounds, and were the heaviest in the flock.

Second Period of Growth.

First Hatch.—At 57 days old the Africans had an average weight of 6.33 pounds, having gained 4.17 pounds each in 21 days, equal

to a daily gain of 3.17 ounces. The Embdens averaged 5.35 pounds, and had gained 3.54 pounds each in the 21 days.

Second Hatch.—The pure Africans were the heaviest birds, averaging 8.94 pounds. The next in weight was the Embden-Toulouse cross, pen 3, which weighed 7.88 pounds each, and pen 8, African-Embden cross, held third place, averaging 7.75 pounds. The greatest daily gain was 3.952 ounces, made by the Africans. The heaviest single bird was an African, which weighed 9.38 pounds.

Third Hatch.—In this hatch the pure Toulouse reached the highest average, 8.64 pounds, and the Embdens came second at 8.16 pounds average weight. The third heaviest birds were from pens 1 and 15, the Embden-African cross, which weighed 7.84 pounds each. The greatest daily gain was made by pen 2, Embden-Brown China cross, which averaged 3.34 ounces. The heaviest three individuals were pure bred birds: first an Embden, 10.00 pounds; second, a Toulouse, 9.44 pounds; and third, an Embden, 9.13 pounds.

Third Period of Growth.

First Hatch.—At 71 days old the Africans averaged 9.87 pounds, having gained, in the fourteen days since the previous weighing, 3.54 pounds, equal to a gain of 4.045 ounces daily. The Embdens included among their number one cripple and one dwarf, which were separately weighed. The average weight of the others was 8.64 pounds, and the gain was 3.30 pounds in 14 days.

Second Hatch.—The pure Africans are the only goslings in this hatch which at 72 days old weigh 11 pounds or over each. They averaged 11.40 pounds, and in fifteen days since the previous weighing gained 2.46 pounds. The heaviest bird in the flock was an African, which weighed 12.38 pounds, and that bird made a daily gain since the *first* weighing, 35 days before, of 3.376 ounces. The greatest average gain, however, for this period, was made by the Toulouse-Embden cross, pen 7, and was equal to 2.805

ounces per day. The African-Embden cross, pen 8, was next in weight to the Africans, averaging 10.16 pounds, and the Toulouse-Embden cross, pen 7, was third in size, averaging 10.03 pounds.

Third Hatch.—At 74 days old the pure Toulouse goslings were the heaviest, averaging 10.18 pounds. The next largest was the Toulouse-Embden cross, pen 7, which averaged 10.03 pounds, and made the greatest gain in the 15 days—2.24 pounds—equal to 2.39 ounces per day. The pure Embdens were third in size, averaging 9.52. The heaviest three individuals in this hatch, at this weighing, were, first, a bird from pen 7, Toulouse-Embden, which weighed 11.50 pounds; second, a pure Toulouse gosling, which weighed 11.13 pounds; and third, an Embden-African, pen 1, which weighed 11.00 pounds.

The following table gives the pure breed or cross which made the greatest daily average gain during each period of growth, and the three matings which produced the heaviest goslings, with the greatest average weight attained at each weighing:

TABLE XXXVI.—*Showing Greatest Average Weights, and Daily Gains at each Weighing, and Matings which produced the Heaviest Three Average Weights.*

HATCH.	HEAVIEST AVERAGE WEIGHT.			2D HEAVIEST AVERAGE WEIGHT.		3D HEAVIEST AVERAGE WEIGHT.		GREATEST DAILY GAIN DURING THE PERIOD.		
	Yard.	Mating.	Pounds.	Yard.	Mating.	Yard.	Mating.	Ounces.	Yard.	Mating.
First Period.										
1st Hatch[1].......	17	African-African........	2.16	6 & 19	Embden-Embden.....	......	....	0.96	17	African-African.
2d "	3	Embden-Toulouse......	4.13	11	African-White China.	17	African-African......	1.78	3	Embden-Toulouse.
3d "	18	Toulouse-Toulouse.....	4.48	6 & 19	Embden-Embden.....	13	White China-Embden.	1.99	18	Toulouse-Toulouse.
Second Period.										
1st Hatch[1].......	17	African-African........	6.38	6 & 19	Embden-Embden.....	......	....	3.17	17	African-African.
2d "	17	" "	8.94	8	Embden-Toulouse....	8	African-Embden......	3.95	17	" "
3d "	18	Toulouse-Toulouse.....	8.64	6 & 19	Embden-Embden.....	1 & 15	Embden-African......	3.34	2	Embden-Brown China.
Third Period.										
1st Hatch[1].......	17	African-African........	9.87	6 & 19	Embden-Embden.....	......	....	4.04	17	African-African.
2d "	17	" "	11.40	8	African-Embden......	7	Toulouse-Embden....	2.80	7	Toulouse-Embden.
3d "	18	Toulouse-Toulouse.....	10.18	7	Toulouse-Embden....	6 & 19	Embden-Embden.....	2.89	7	Toulouse-Embden.

[1] Only Africans and Embdens included in this hatch.

In this table the results of nine weighings are given, and we find that the pure bred Africans reached the greatest average weight five times, held third place once, and made the greatest daily gain four times. Pure bred Toulouse held the first place three times, and made the greatest daily gain once. The Embden-Toulouse cross, pen 3, were the heaviest birds once, second heaviest once, and made the greatest daily gain once. The pure bred Embdens did not once reach the first place, but ranked second five times, and third once. The Toulouse-Embden cross, pen 7, ranked second and third, once each, and twice made the greatest daily gain. The African-Embden cross, pen 8, ranked second once, and third once. The other pens which appear once each in this table are numbers 1 and 15, 2, 11, and 13. Those which do not appear are pens 4, 5, 9, 10, 14, 16, 20, and 21. The lowest average weights were recorded for the Brown China-Toulouse twice, and the following matings once each: African-White China, White China-Brown China, pure Toulouse, and White China-Embden. This table should be compared with table XII, which comprises the results of the weighings in 1896. It will be seen that the pure bred birds, of which, excepting Africans, there were very few specimens in 1896, have this season made an excellent showing as compared with the crosses. A slightly greater average weight was reached by the Africans, in each of the second and third periods of growth in 1897, than was attained by the progeny of *any mating* in 1896 during a similar period.

In the three following tables the goslings of the three hatches are considered together, and the average weight of all the birds from each mating given. The daily gain from date of hatching to time of weighing is determined by getting the total number of days' growth for all the birds from each mating, and using it as a divisor for the total weight. The gains per day are given in ounces. No attention has been paid to the weights of the goslings when hatched.

TABLE XXXVII.—*First Weighing, Goslings 36-37 Days Old, 1897.*

YARD No.	MATING.	No. of goslings.	Total No. of days' growth.	Total weight. Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1 & 15	Embden-African..........	17	618	55.32	3.25	1.432
2	Embden-Brown China....	9	331	30.19	3.35	1.459
3	Embden-Toulouse...... .	7	253	22.63	3.23	1.430
4	White China-Brown China.	3	108	6.63	2.21	.980
7	Toulouse-Embden.........	6	214	19.19	3.19	1.433
8	African-Embden.....	9	328	30.19	3.35	1.472
9	Brown China-Embden....	1	37	3.38	3.38	1.460
10	Embden-White China.....	6	216	17.81	2.97	1.318
11	African-White China......	8	291	22.94	2.86	1.134
13	White China-Embden.....	2	73	6.69	3.34	1.465
14	Brown China-Toulouse....	5	184	14.32	2.86	1.244
16	Brown China-White China.	1	36	2.56	2.56	1.137
17	African-African..........	6	218	17.75	2.95	1.302
18	Toulouse-Toulouse...... .	12	441	44.18	3.67	1.600
19 & 6	Embden-Embden...... ...	28	1,014	79.25	2.83	1.389
20	Toulouse-White China....	2	73	6.75	3.37	1.478

TABLE XXXVIII.—*Second Weighing, Goslings 57–59 Days Old, 1897.*

Yard No.	Mating.	No. of goslings.	Total No. of days' growth.	Total weight. Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1 & 15	Embden-African	17	991	129.00	7.58	2.082
2	Embden-Brown China.....	9	517	64.81	7.20	2.004
3	Embden-Toulouse	6	352	42.82	7.13	1.945
4	White China-Brown China.	3	177	17.00	5.66	1.506
7	Toulouse-Embden	6	350	46.00	7.66	2.002
8	African-Embden..	7	407	53.38	7.62	2.097
9	Brown China-Embden	1	57	6.88	6.88	1.921
10	Embden-White China.....	6	354	39.38	6.58	1.779
11	African-White China......	8	466	49.06	6.13	1.688
13	White China-Embden.....	2	116	14.57	7.28	2.009
14	Brown China-Toulouse....	4	228	27.63	6.90	1.937
16	Brown China-White China.	1	59	6.13	6.13	1.660
17	African-African	6	344	44.38	7.39	2.064
18	Toulouse-Toulouse........	11	633	80.88	7.35	2.017
19 & 6	Embden-Embden	27	1,557	181.13	6.70	1.861
20	Toulouse-White China...	2	116	14.88	7.44	2.051

TABLE XXXIX.—*Third Weighing, Goslings 71-74 Days Old, 1897.*

Yard No.	Mating.	No. of goslings.	Total No. of days' growth.	Total weight. Pounds.	Average weight. Pounds.	Average growth per day. Ounces.
1 & 15	Embden-African..........	17	1,246	155.18	9.12	1.993
2	Embden-Brown China.....	9	652	80.63	8.95	1.975
3	Embden-Toulouse	6	442	52.06	8.67	1.883
4	White China-Brown China.	3	222	19.06	6.35	1.373
7	Toulouse-Embden	6	440	60.19	10.03	2.177
8	African-Embden..........	7	512	67.75	9.67	2.116
9	Brown China-Embden....	1	72	8.44	8.44	1.875
10	Embden-White China. ..	5	370	42.06	8.41	1.817
11	African-White China......	8	586	61.00	7.62	1.664
13	White China-Embden.....	2	146	17.50	8.75	1.916
14	Brown China-Toulouse...	4	288	35.94	8.98	1.995
16	Brown China-White China.	1	74	8.13	8.13	1.756
17	African-African	6	431	61.44	10.24	2.280
18	Toulouse-Toulouse........	11	798	99.87	9.08	2.001
19 & 6	Embden-Embden...... ..	25[1]	1,808	228.44	9.13	2.020
20	Toulouse-White China.. .	2	146	18.75	9.37	2.054

[1] Dwarf and cripple from hatch of April 2d omitted.

If we take from the tables the four pure breeds or crosses which at each weighing had made the best daily gains, we have the following:

First Weighing, Goslings 36 to 37 days old.

Yard 18	Toulouse pure bred, first,	1.600 ounces.
" 20	Toulouse-White China cross, second,	1.478 "
" 8	African-Embden cross, third,	1.472 "
" 13	White China-Embden cross, fourth,	1.465 "

Second Weighing, Goslings 57 to 59 Days Old.

Yard 8	African-Embden cross, first,	2.097 ounces.
" 1 and 15......	Embden-African cross, second,	2.082 "
" 17..........	African, pure bred, third,	2.064 "
" 20..........	Toulouse-White China cross, fourth,	2.051 "

Third Weighing, Goslings 71 to 74 Days Old.

Yard 17.........	African, pure bred, first,	2.280 ounces.
" 7.............	Toulouse-Embden cross, second,	2.177 "
" 8	African-Embden cross, third,	2.116 "
" 20	Toulouse-White China cross, fourth,	2.054 "

The smallest gains which had been made at each of the three weighings were the following:

First weighing,	Yard 4,	White China-Brown China cross,	0.980 ounces.
Second "	" 4,	" " "	1.506 "
Third "	" 4,	" " "	1.373 "

The three varieties of geese bred pure take the following rank as determined by average size and daily gain:

First weighing, Yard 18	Toulouse,	1.600	ounces, daily gain.
" " " 19 and 6.	Embden,	1.389	" "
" " " 17.............	African,	1.302	" "
Second weighing, Yard 17..........	African,	2.064	" "
" " " 18..........	Toulouse,	2.017	" "
" " " 19 and 6....	Embden,	1.861	" "

Third weighing, Yard 17	African,	2.280	ounces, daily gain.
" " " 19 and 6	Embden,	2.020	" "
" " " 18	Toulouse,	2.001	" "

GREEN GEESE.

The second hatch of goslings was shut up for fattening after being weighed for the third time. The crossbred birds only were fattened, the pure bred goslings being reserved for breeding purposes. Twenty-nine birds were fattened. They were penned up July 10th, and after two days of preliminary feeding, they were fed upon scalded dough made from Indian meal and beef-scraps, as heretofore described. These birds were killed and dressed, and on the morning of August 11th shipped to Boston.

The crossbred goslings of the second hatch, at 72 days old, exclusive of the pure bred Africans, Embdens, and Toulouse, averaged 9.10 pounds. When dressed at 102 days old their average live weight was 11.01 pounds, showing an average gain of 1.91 pounds, or 1.02 ounces per day, during the fattening period. The average dressed weight was 10.65 pounds. The dressed weight was 96.73 per cent. of the live weight.

On August 12th the third hatch was penned up for fattening. This hatch had received its third weighing on August 7th. There were 44 birds in the lot, and they were fed liberally with the regular fattening ration until September 6th and 7th, when they were dressed and sent to Boston. The crossbred goslings of the third hatch averaged at 74 days old 8.63 pounds in weight. When dressed at 101 days old they averaged 10.53 pounds, showing a gain of 1.90 pounds, or 1.12 ounces per day, while fattening. The average dressed weight was 10.13 pounds. The dressed weight was 96.19 per cent. of the live weight.

The lots were not divided as last season, but all were sent to one party. The live and dressed weights are given in the following tables with comments of commission men, and notes upon the color of plumage, bill, feet, nails, and claws. The average weights of each mating are also given :

TABLE XL.—*Showing Live and Dressed Weights of 2d Hatch Goslings Dressed August 9th and 10th, 1897, with Comments of Commission Merchants and Notes Relating to Color, etc.*

DATE.	Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	ESTIMATES OF QUALITY BY COMMISSION MERCHANTS.	NOTES RELATING TO COLOR, ETC.
Aug. 9.	1 & 15	Embden-African...	12.00	11.25	Good stock. Classed No. 1.	Three birds, African type, two white and one pied. The three former had black bills, nails and claws, with greenish legs.
" "	"	" " ...	10.00	9.56		
" "	"	" " ...	9.94	9.44		
" "	"	" " ...	9.44	9.13		
" "	"	" " ...	11.44	11.13		
" "	"	" " ...	13.75	13.63		
		Average.........	11.09	10.69		
Aug. 9.	2	Embden-Br. China.	11.06	10.63	Good stock. Classed No. 1.	One dark, Brown China type, the others pied. The dark bird had black bill, nail and claws, with greenish legs. One pied bird had a mottled bill, others light yellow bills. Three had mottled nails, others white. All had yellow legs, two had mottled claws, and those of the others were white.
" "	"	" " .	13.06	12.50		
" "	"	" " .	11.13	10.88		
" "	"	" " .	10.19	9.81		
" "	"	" " .	9.13	8.44		
" "	"	" " .	9.00	9.19		
" "	"	" " .	10.50	10.13		
		Average.........	10.58	10.15		
Aug. 9.	3	Embden-Toulouse..	11.25	10.88	Classed No. 2.	Toulouse type. Mottled bill, with black nail, yellow legs and black claws.
Aug. 9.	7	Toulouse-Embden..	13.63	13.88	Good stock. Classed No. 1.	One bird slate color. Toulouse type. Yellow bill, black nail, light yellow legs and black nails. Other bird pied, with light yellow bill and legs, with white nail and claws.
" "	"	" " ..	13.63	13.13		
		Average.........	13.63	13.15		
Aug. 9.	8	African-Embden...	12.00	11.81	Classed No. 2.	Three birds African type, one pied, about half white. Latter had light yellow bill and orange legs, with mottled nail and claws. Bills of others, two mottled, one black. Legs, two dark yellow, one olive. Nails all black; claws, two black, one white.
" "	"	" " ...	12.44	12.00		
" "	"	" " ...	10.81	10.88		
" "	"	" " ...	11.50	11.44		
		Average.........	11.68	11.53		
Aug. 9.	11	African-Wh. China.	10.31	9.88	Classed No. 3.	Two were African type and one Brown China type. All had black bills, nails and claws, and dark yellow legs.
" "	"	" " .	9.63	9.31		
" "	"	" " .	8.13	8.25		
		Average.........	9.35	9.14		
Aug. 9.	13	Wh. China-Embden	9.88	9.44	Classed No. 2.	White. Light yellow bill, yellow legs, and white nail and claws.

TABLE XL.—*Continued.*

DATE.	Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	ESTIMATES OF QUALITY BY COMMISSION MERCHANTS.	NOTES RELATING TO COLOR, ETC.
Aug. 9.	14	Br. China-Toulouse.	11.50	10.81	Classed No. 2.	Toulouse type and color. Bills mottled, with black nails. Legs varied from light to dark olive. Claws, three black and one mottled.
" "	"	" " .	12.69	12.25		
" "	"	" " .	10.06	9.81		
" "	"	" " .	10.38	10.00		
		Average.........	11.15	10.71		
Aug. 9.	20	Toulouse-Wh.China	10.87	10.44	Classed No. 2.	Toulouse type. Mottled bill, light yellow legs, black nail and claws.

TABLE XLI.—*Showing Live and Dressed Weights of 3d Hatch Goslings Dressed September 6th and 7th, 1897, with Comments of Commission Merchants, and Notes Relating to Color, etc.*

DATE.	Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	ESTIMATES OF QUALITY BY COMMISSION MERCHANTS.	NOTES RELATING TO COLOR, ETC.
Sept. 6.	1 & 15	Embden-African....	9.94	9.44	Second best geese in the lot.	One dark bird of African type, with black bill, nail and claws, and dark yellow legs. Seven others pied, and three white. All had light yellow bills and legs, nine had white nails, one was mottled, and all had white claws.
" "	"	" "	11.25	11.44		
" "	"	" "	10.75	10.00		
" "	"	" "	13.56	13.19		
" "	"	" "	11.38	9.69		
" "	"	" "	11.06	11.00		
" "	"	" "	12.25	11.88		
" "	"	" "	13.25	12.63		
" "	"	" "	11.38	10.88		
" "	"	" "	11.81	11.31		
" "	"	" "	10.06	9.50		
		Average.........	11.51	10.99		
Sept. 6.	2	Embden-Br. China.	10.56	10.31	Fair.	One all white, except one dark feather in one wing, light yellow bill and legs, with white nail and claws. One pied, but very dark yellow bill, black nail, and lemon colored legs, one black, and five white claws.
" "	"	" "	10.63	10.63		
		Average.........	10.59	10.47		
Sept. 6.	3	Embden-Toulouse..	11.38	11.44	Fair.	Two white and one pied, all with light yellow bills and legs, white nails and claws. The other bird was Toulouse type and color, with mottled bill, yellow legs, and black nail and claws.
" "	"	" " ..	9.94	9.44		
" "	"	" " ..	11.00	10.56		
" "	"	" " ..	7.75	7.50		
		Average.........	10.01	9.73		

TABLE XLI.—*Continued.*

DATE.	Yard No.	MATING.	Live weight. Pounds.	Dressed weight. Pounds.	ESTIMATES OF QUALITY BY COMMISSION MERCHANTS.	NOTES RELATING TO COLOR, ETC.
Sept. 6.	4	Wh. China-Br. China	11.31	11.25	Fair.	All Brown China type and color. One all dark, one mottled, and one yellow bill, two with dark yellow, and one with mottled legs; all with black nails and claws.
" "	"	" "	8.38	7.06		
" "	"	" "	10.19	9.75		
		Average.........	9.96	9.35		
Sept. 6.	7	Toulouse-Embden..	9.94	9.63	Fair.	One dark bird, Toulouse type, with light yellow bill, yellow legs, and black nail and claws. Others, one white and two pied. All with light yellow bills and legs, white nails and claws.
" "	"	" " ..	10.44	10.13		
" "	"	" " ..	12.50	11.94		
" "	"	" " ..	13.63	12.94		
		Average.........	11.62	11.16		
Sept. 6.	8	African-Embden...	8.81	9.00	Fair.	Two African type and color. Bills, one black and one mottled. Legs, yellow, nails and claws, black. Two pied birds, mottled bills, yellow legs, with white nails and claws.
" "	"	" " ...	11.19	11.19		
" "	"	" " ..	10.06	9.94		
" "	"	" " ...	11.88	11.88		
		Average.........	10.36	10.50		
Sept. 6.	10	Embden-Wh. China.	12.81	11.50	The best shaped, plumpest, and in every way a little superior to the others.	Three pied and two white birds. All had light yellow bills and legs, white nails and claws.
" "	"	" " .	11.94	11.69		
" "	"	" " .	7.94	7.50		
" "	"	" " .	10.25	8.38		
" "	"	" " .	10.06	9.81		
		Average.........	10.50	9.77		
Sept. 6.	11	African-Wh. China..	8.25	9.00	Third best birds.	All white birds with light yellow bills and legs, white nails and claws.
" "	"	" " ..	7.81	7.56		
" "	"	" " ..	8.25	8.00		
" "	"	" " ..	9.50	7.50		
" "	"	" " ..	8.00	7.75		
		Average.........	8.36	7.96		
Sept. 6.	13	Wh. China-Embden.	11.25	10.63	Good bird.	White, with light yellow bill and legs, white nail and claws.
Sept. 6.	16	Br. China-Wh.China.	10.06	10.50	Fair.	Brown China type, dark mottled bill, dark yellow legs, black nail and claws.

The goslings shipped August 11th brought 15 cents per pound, although had the whole lot corresponded with the poorer grades the price would have been less. There was some criticism on account of pin-feathers, which were especially injurious to the

appearance of the dark feathered birds, and which could only be removed by using a sharp knife, and picking them out individually. The influence of Embden blood in the crosses, as illustrated by the production of white or pied birds with yellow bills, is a point of value to the practical breeder, as such birds are more easily dressed and sell better in the market.

The Embden-African, Embden-Brown China, and Toulouse-Embdem crosses were considered about equal in quality, and classed as the best goslings.

The third hatch, dressed the 6th and 7th of September, sold for 14 cents per pound, and was commended as the best looking lot sent, taking all the crosses together. Especial pains were taken by the pickers to remove *all* pin-feathers. The Embden-White China cross received the highest commendation for both form and appearance, and the Embden-African cross was the next choice. The African-White China cross was selected as third in point of quality and appearance. In this hatch this cross was all *white birds with yellow bills,* while in the second hatch this same cross was all colored like the pure African or Brown-China geese, and the three goslings in the shipment were considered "especially rough" in appearance. This serves to show the advantage that white feathers and yellow bills have over dark feathers and black bills. In table XLII the live and dressed average weights of both hatches are given, and the daily gains while fattening as well as the per cent. of dressed to live weight.

TABLE XLII.—*Showing Total and Daily Gains made by Goslings in Second and Third Hatches, 1897, During Fattening Period, and Per Cents. of Dressed to Live Weight.*

Yard No.	Matings.	Hatch.	No. of Goslings.	Average live weight at time of dressing. Pounds.	Average gain in fattening period. Pounds.	Average daily gain in ounces.	Average dressed weight. Pounds.	Per cent. of dressed to live weight.
1 & 15	Embden-African.......	2nd	6	11.09	2.06	1.10	10.69	95.9
1 & 15	" "	3rd	11	11.51	2.34	1.25	10.99	
2	Embden-Brown China ..	2nd	7	10.58	1.71	.91	10.15	97.4
2	" " " ..	3rd	2	10.59	1.34	.71	10.47	
3	Embden-Toulouse . ..	2nd	1	11.25	1.94	1.03	10.88	96.9
3	" "	3rd	4	10.01	1.46	.77	9.73	
4	White China-Br. China..	3rd	3	9.96	3.61	1.96	9.35	93.8
7	Toulouse-Embden.......	2nd	2	13.63	3.60	1.92	13.15	96.3
7	" "	3rd	4	11.62	1.59	.84	11.16	
8*	African-Embden..	2nd	4	11.68	1.52	.81	11.53	99.5
8*	" "	3rd	4	10.36	1.05	.56	10.50	
10	Embden-White China...	3rd	5	10.50	2.09	1.11	9.77	93.0
11	African-White China....	2nd	3	9.35	.83	.44	9.14	96.5
11	" " "	3rd	5	8.36	1.28	.68	7.96	
13	White China-Embden...	2nd	1	9.88	1.63	.87	9.44	95.0
13	" " "	3rd	1	11.25	2.00	1.16	10.63	
14	Brown China-Toulouse .	2nd	4	11.15	2.17	1.15	10.71	96.0
16	Br. China-White China..	3rd	1	10.06	1.93	1.02	10.50	104.4*
20	Toulouse-White China..	2nd	1	10.87	1.81	.96	10.44	96.0

* Unless an error was made in taking live weight of this bird, ice water was absorbed in the process of cooling.

The heaviest goslings were the Toulouse-Embden cross, pen 7, in the second hatch, which averaged 13.15 pounds dressed weight. The same cross in the third hatch averaged 11.16 pounds. The African-Embden cross, pen 8, in the second hatch, averaged 11.53 pounds dressed, which was next to the heaviest average. The gains during the fattening period were much less than those secured in 1896. The greatest average daily gain was 1.96 ounces, for pen 4, White China-Brown China cross, and Toulouse-Embden, pen 7, was only a little less, 1.92 ounces per day. In 1896 the Embden-African cross gained 2.48 ounces per day, and the Embden-Toulouse and African-Toulouse crosses both exceeded 2 ounces gain per day. The lowest daily gain secured in both hatches, and the only one less than 1.07 ounces, was 0.96 of an ounce, in the case of the White China-Embden cross. In 1897 no less than six crosses failed to make a daily gain of one ounce, and the lowest daily gain was 0.44 of an ounce, in the case of the African-White China cross. As the geese were fed in the same way and by the same man in 1897 as in 1896, we can only account for the difference by the greater size of the fattening pen and the consequent greater inducement for the geese to move about, or because they were confined for a longer time. An unused poultry yard was utilized as a fattening pen in 1897, and it was a little more than twice as large in area as the pen used in 1896. The age, average weights, and daily gains of the goslings, previous to being penned for fattening, were as follows for the two years:

First hatch goslings, 1896, 70 days old, average live weight 8.57 pounds, 1.96 ounces daily growth.

Third hatch goslings, 1896, 69 days old, average live weight 7.82 pounds, 1.81 ounces daily growth.

Second hatch goslings, 1897, 72 days old, average live weight 9.10 pounds, 2.02 ounces daily growth.

Third hatch goslings, 1897, 74 days old, average live weight 8.63 pounds, 1.86 ounces daily growth.

At the end of the fattening period, the age, average weights, and daily gains, *during the period of fattening*, were as follows:

First hatch goslings, 1896, 97 days old, penned 23 days, average live weight 11.52 pounds, 1.75 ounces daily gain.

Third hatch goslings, 1896, 98 days old, penned 25 days, average live weight 10 86 pounds, 1.67 ounces daily gain.

Second hatch goslings, 1897, 102 days old, penned 30 days, average live weight 11.01 pounds, 1 02 ounces daily gain.

Third hatch goslings, 1897, 101 days old, penned 27 days, average live weight 10.53 pounds, 1.12 ounces daily gain.

In the case of the goslings fattened in 1896, four days intervened between the date of weighing and the time when they were penned up, during which they ran on pasture and were fed as usual. In getting the daily gain, however, those days are counted with the days during which they were penned up. In 1897 they were penned as soon as weighed, and hence were shut up a few days longer. The average weights and daily growth of the 1897 hatches, at time of penning up, were respectively greater than those of 1896, but at the end of the fattening period the average weights and daily gains, during the period, reached by the 1896 hatches, exceeded those of the 1897 goslings. If the 1897 goslings had been allowed a week more upon pasture, and then been confined a less number of days for fattening, the gains would doubtless have been greater.

Table XLIII includes the total and average live and dressed weights of all the green geese dressed in the two years, and the number of birds from each mating. Only five pure bred goslings are included—four Africans and one Embden. Probably had a larger number of Embdens been fattened and dressed the average weights would have been greater than with this one specimen.

TABLE XLIII.—*Showing the Average Live and Dressed Weights of Green Geese from each Mating, fattened in 1896 and 1897, and the Average Weights of all Green Geese in each Cross.*

Yard No.	Mating.	Year.	Hatch.	No. of goslings.	Live Weight. Total pounds.	Live Weight. Average pounds.	Dressed Weight. Total pounds.	Dressed Weight. Average pounds.
1	Toulouse-African.	1896	1st	5	62.14	12.43	58.63	11.72
1	" "	1896	3rd	1	10.25	10.25	10 00	10.00
				6	72.39	12.06	68.63	11.43
2	Embden-Brown China .	1896	1st	1	12.69	12.69	12.38	12.38
2	" " ..	1896	3rd	1	9.25	9.25	9.13	9.13
2	" " ..	1897	2nd	7	74.07	10.58	71.08	10.15
2	" " ..	1897	3rd	2	21.19	10.59	20.94	10.47
				11	117.20	10.65	113.53	10.32
3	Embden-Toulouse	1896	1st	1	10.44	10.44	10.00	10.00
3	" "	1896	3rd	5	58.50	11.70	56.13	11.22
3	" "	1897	2nd	1	11.25	11.25	10.88	10.88
3	" "	1897	3rd	4	40.07	10.01	38.94	9 73
				11	120.26	10.93	115.95	10.54
4	African-Toulouse.......	1896	1st	8	98.77	12.34	95.26	11.90
4	White China-Br. China..	1897	3rd	3	29.88	9.96	28.06	9.35
5	Brown China-African..	1896	3rd	2	18.13	9.06	17.50	8.75
7	Toulouse-Embden.....	1897	2nd	2	27.26	13.63	26.51	13.15
7	" "	1897	3rd	4	46.51	11.62	44.64	11.16
				6	73.77	12.29	71.15	11.85
8	African-Embden..	1896	1st	4	45.45	11.36	43.44	10.86
8	" "	1896	3rd	3	33.04	11.02	31.56	10.52
8	" "	1897	2nd	4	46.75	11.68	46.13	11.53
8	" "	1897	3rd	4	41.44	10.36	42.01	10.50
				15	166.68	11.11	163.14	10.87

TABLE XLIII.—*Continued.*

Yard No.	Mating.	Year.	Hatch.	No. of goslings.	Live Weight. Total pounds.	Live Weight. Average pounds.	Dressed Weight. Total pounds.	Dressed Weight. Average pounds.
9	Brown China-Embden ..	1896	1st	4	43.01	10.75	41.19	10.29
9	" " ..	1896	3rd	3	31.32	10.44	30.26	10.09
				7	74.33	10.61	71.45	10.20
10	Brown China-Embden ..	1896	3rd	1	10.50	10.50	10.13	10.13
10	" " ..	1897	3rd	5	52.50	10.50	48.88	9.77
				6	63.00	10.50	59.01	9.83
11	Toulouse-Brown China..	1896	1st	5	50.89	10.18	49.32	9.86
11	" " ..	1896	3rd	7	71.76	10.25	69.88	9.98
				12	122.65	10.22	119.20	9.93
11	African-White China....	1897	2nd	3	28.07	9.35	27.44	9.14
11	" "	1897	3rd	5	41.81	8.36	39.81	7.96
				8	69.88	8.73	67.25	8.40
12	African-Brown China...	1896	1st	12	120.38	10.03	117.45	9.78
12	" " ...	1896	3rd	6	57.88	9.64	56.20	9.36
				18	178.26	9.90	173.65	9.64
13	White China-Embden...	1896	1st	1	9.44	9.44	9.44	9.44
13	" " ...	1896	3rd	1	8.25	8.25	8.19	8.19
13	" " ...	1897	2nd	1	9.88	9.88	9.44	9.44
13	" " ...	1897	3rd	1	11.25	11.25	10.63	10.63
				4	38.82	9.70	37.70	9.47
14	Brown China-Toulouse..	1896	1st	4	43.31	10.82	41.69	10.42
14	" " ..	1896	3rd	10	122.70	12.27	118.71	11.87
14	" " ..	1897	2nd	4	44.63	11.15	42.87	10.71
				18	210.64	11.69	203 27	11.28

TABLE XLIII.—*Continued*

Yard No.	Mating.	Year.	Hatch.	No. of goslings.	Live Weight. Total pounds.	Live Weight. Average pounds.	Dressed Weight. Total pounds.	Dressed Weight. Average pounds.
15	Embden-African.......	1896	1st	9	126.33	14.03	121.25	13.47
15	" "	1896	3rd	1	12.13	12.13	11.88	11.88
15 & 1	" "	1897	2nd	6	66.57	11.09	64.14	10.69
15 & 1	" "	1897	3rd	11	126.69	11.51	120.96	10.99
				27	331.72	12.28	318.23	11.78
16	Brown China-Wh. China	1897	3rd	1	10.06	10.06	10.50	10.50
17	African-African	1896	1st	2	24.44	12.22	23.38	11.69
17	" "	1896	3rd	2	25.69	12.84	24.63	12.31
				4	50.13	12.53	48.01	12.00
19	Embden-Embden......	1896	1st	1	9.13	9.13	8.81	8.81
20	Toulouse-White China..	1897	2nd	1	10.87	10.87	10.44	10.44
21	White China-Toulouse..	1896	3rd	2	19.32	9.66	19.31	9.65

If we first compare the averages made by the different hatches, we find that the greatest average weights, as green geese, reached by the goslings of any mating in the two years was 14.03 pounds live weight, 13.47 pounds dressed weight, for 9 Embden-African crossbred goslings, pen 15, the first hatch in 1896. The heaviest of these goslings weighed alive, at 97 days old, 15.94 pounds, which was the greatest individual weight reached by any green goose. Two others weighed alive 15 pounds or more each, and still two others over 14 pounds each.

Note.—The goslings in the 1st hatch, 1896, were 97 days old when dressed for market.
" " " " 3rd " " " 98 " " " " " "
" " " " 2nd " 1897, " 102 " " " " " "
" " " " 3rd " " " 101 " " " " " "

The next heaviest record was for the second hatch in 1897, for pen 7, Toulouse-Embden cross. In this case two birds averaged 13.63 pounds live weight, and 13.15 dressed.

Pure bred Africans, pen 17, from the third hatch in 1896, take third rank with an average live weight for two birds of 12.84 pounds, and 12.31 pounds dressed weight.

The lowest record in the table is that for one White China-Embden bird, pen 13, from the third hatch in 1896, 8.25 pounds alive, and 8.19 pounds dressed. The average of five birds in the third hatch, 1897, from pen 11, African-White China cross, is next the lowest for live weight, 8.36 pounds, and lowest of all for dressed weight, 7.96 pounds.

If we now consider the average results obtained from the total weight of all the green geese in the several hatches from each mating, we find that three different matings are represented by only one goose each, two crosses by only two geese each, and one by three geese. The others vary from four to twenty-seven each in number.

The five matings which produced birds averaging over twelve pounds live weight, are as follows:

MATINGS.	No. of yard.	No. of goslings.	Average live weight.	Average dressed weight.
African, pure	17	4	12.53	12.00
African-Toulouse	4	8	12.34	11.90
Toulouse-Embden	7	6	12.29	11.85
Embden-African	15	27	12.28	11.78
Toulouse-African	1	6	12.06	11.43

The pure bred Africans stand at the head of the list, but a smaller number of individuals is included than in the case of any of the crosses, and their average weights are considerably exceeded by the weights of the Embden-African cross, pen 15, for

the year 1896. In 1897 this cross was bred from different stock, and did not reach the size secured in 1896, and the two year average is thus reduced. In 1896, eight out of the ten Embden-African crossbred birds exceeded in live weight the average of the Africans in the above table, but in 1897 only three out of seventeen were above that figure. For quality, the Embden-African cross has been classed No. 1 in four shipments, and No. 2 in the fifth. In four shipments of one bird each in the case of the Africans, one only was commended as "one of the best," the others were classed "No. 2," "fair," and "not recommended." In the case of the Toulouse-African cross, pen 1, and the opposite, pen 4, five shipments were made, two of which were pronounced "good birds but appearance against them," two other shipments were classed as "No. 3" and "No 4," and the last as "below the usual grade received." The Toulouse-Embden cross, pen 7, was classed "No. 1" in one shipment, and "fair" in the other.

SHRINKAGE IN DRESSING AND DRAWING.

A few crossbred geese were kept until November, and killed at that time with a few Embdens and Africans culled from the pure breds reserved for breeding purposes. These geese were sold in the vicinity, and thus the "drawn weights," that is, the weights of the birds when ready for cooking, were obtained. From these weights the percentage of dressed to live weight, of drawn to dressed weight, and of drawn to live weight, have been calculated. At the end of this table are given the average percentages for all the young geese, and, for comparison, the weights and percentages obtained in dressing one old gander, and also the figures for a lot of twenty old hens. These figures show that there is less than 5 per cent. loss in live weight in the process of dressing for market in the case of geese, and over 13 per cent. in the case of hens. The drawn weight in the case of young geese is 71.65 per cent. of the dressed weight, while with hens it was 75 per cent. When we compare the drawn weight with the live weight, the figures for

the young geese were 68.11 per cent., for the old goose 62.66 per cent., and for the hens 64.02 per cent. There is thus shown to be 4.09 per cent. more shrinkage in the case of old fowls than in the case of young geese, between drawn weight and live weight.

The corresponding figures for all the geese raised in 1896, and dressed and drawn during the fall and early winter, have been included in table XLV, with the averages and percentages calculated for each different mating. Altogether, 17 different matings are represented in the two tables.

The greatest shrinkage between live and drawn weight is found in table XLIV, in the case of an Embden-Toulouse cross, pen 3, where the drawn weight was only 63.94 per cent. of the live weight. The least shrinkage is also in the same table, and recorded in the case of the White China-Brown China cross, where the drawn weight was 76.05 per cent. of the live weight. The average percentage for 19 geese from 9 different matings was 68.11, showing a shrinkage from live to drawn weight of 31.89 per cent. The average shrinkage between live and dressed weight was 4.88 per cent.

TABLE XLIV.—*Live, Dressed and Drawn Weights of Mature Young Geese Killed November 11th and 24th, 1897.*

Yard.	Mating.	Live Weights.				Dressed Weights.[1]				Drawn Weights.[2]				Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight
		Lbs.	Oz.	Total lbs.	Avg. lbs.	Lbs.	Oz.	Total lbs.	Avg. lbs.	Lbs.	Oz.	Total lbs.	Avg. lbs.			
2	Embden-Brown China	16	0	16.00	16.00	15	1	15.06	15.06	10	11	10.69	10.69	94.12	70.98	66.81
3	Embden-Toulouse	14	9	14.56	14.56	13	9	13.56	13.56	9	5	9.81	9.81	93.13	68.65	63.94
4	White China-Brown China	9	2			8	11	....	....	6	0	....	....	....		
"	" "	11	4	20.38	10.19	11	0	19.69	9.84	9	8	15.50	7.75	96.56	78.76	76.05
11*	African-White China	9	5	....	....	9	0	....	....	....	....	....	....	....	....	....
"	" "	9	14	....	....	9	8	....	....	6	12			....		....
"	" "	10	10	20.50	10.25	10	5	19.81	9.90	7	6	14.13	7.06	96.58	71.81	68.87
13	White China-Embden	11	13	11.81	11.81	11	2	11.13	11.13	8	1	8.06	8.06	94.24	72.41	68.24
14	Brown China-Toulouse	15	14	....	....	15	0	....	....	10	2	....	....	....	..	
"	" "	14	12	30.63	15.31	14	0	29.00	14.50	10	0	20.13	10.06	94.70	69.37	65.05
17	African-African	17	0	....	....	16	2	....	....	11	12	....	....	....		....
"	" "	14	14		....	13	14	....	....	9	14	....	....	....	....	....
"	" "	13	6	45.25	15.08	13	0	43.00	14.83	8	6	30.00	10.00	95.02	69.77	66.31
19*	Embden-Embden	13	2	....	....	12	10	....	....	....		....	....	....	..	....
"	" "	14	6	....	....	13	15	....	....	9	13	....	....	....	....	....
"	" "	13	10	....	....	13	1	....	....	9	4	....	....	..		....
"	" "	19	7	47.44	15.81	18	8	45.50	15.16	12	13	31.88	10.62	95.88	70.05	67.17
20	Toulouse-White China	12	5	....	....	11	13	....	....	8	11	....	....	....		....
"	" "	19	9	31.88	15.94	18	14	30.69	15.34	13	13	22.50	11.25	96.28	73.83	70.57
	Average of 9 lots of young geese (19 specimens)													95.12	71.65	68.11
	1 old African gander, live weight 17.06 lbs., dressed weight 16.87 lbs., drawn weight 10.69 lbs													95.95	65.36	62.66
	20 old hens killed, live weight 139.00 lbs., dressed weight 120.00 lbs., drawn weight 90.00 lbs.													86.33	75.00	64.02

* Not included in totals and averages, because not drawn.
[1] As sold in the markets.
[2] Thoroughly cleaned, ready for cooking.

TABLE XLV.—*Live, Dressed and Drawn Weights of Mature Young Geese, Killed at Different Times, from November 3rd, 1896, to February 17th, 1897.*

Yard.	Mating.	Live Weights. Lbs.	Live Weights. Oz.	Live Weights. Total lbs.	Live Weights. Avg. lbs.	Dressed[1] Weights. Lbs.	Dressed[1] Weights. Oz.	Dressed[1] Weights. Total lbs.	Dressed[1] Weights. Avg. lbs.	Drawn[2] Weights. Lbs.	Drawn[2] Weights. Oz.	Drawn[2] Weights. Total lbs.	Drawn[2] Weights. Avg. lbs.	Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
1	Toulouse-African........	15	13	15.81	15.81	15	6	15.38	15.38	10	13	10.81	10.81	97.28	70.28	68.37
2	Embden-Brown China..	12	10	....	....	11	11	......	.....	8	7	......	......	.....	....	.....
"	" "	14	15	......	......	13	14	.....		10	1	.....	..	.....	......	
"	" "	12	4	39.81	13.27	11	6	36.94	12.31	9	5	27.81	9.27	92.81	75.28	69.85
3	Embden-Toulouse........	13	15		......	13	3	....	.....	9	6	......	.. ..	....	......	......
"	" "	12	8	.....		13	4	......	......	9	12	......	......	......	......	......
"	" "	14	2	40.56	13.52	13	6	39.81	13.27	10	0	29.13	9.71	98.15	73.17	71.81
4	African-Toulouse........	18	13	.....	......	17	14	.		12	12	....	.....	......	.....	......
"	" "	14	9	33.38	16.69	14	5	32.19	16.09	10	12	23.50	11.75	96.43	73.00	70.40
5	Brown China-African ..	11	8	11.50	11.50	10	12	10.75	10.75	8	9	8.56	8.56	93.48	79.62	74.43
8	African-Embden.........	13	12	.....	.....	12	10	...	....	8	11	......	......	.	.....	.....
"	" "	16	1	......	......	15	0	....	......	10	7	.....	.....	...	....	.....
"	" "	15	8	45.31	15.10	15	0	42.63	14.21	11	8	30.63	10.21	94.08	71.85	67.61
9	Brown China-Embden....	11	10	......	.....	11	2	....	.....	8	2	......	.....	....	....	......
"	" "	13	1	...	......	13	0	......	......	9	8	......	......	....	......	......
"	" "	12	14	37.56	12.52	12	10	36.75	12.25	8	14	26.50	8.83	97.84	72.10	70.55
11	Toulouse-Brown China...	12	13	12.81	12.81	12	2	12.13	12.13	8	9	8.56	8.56	94.69	70.56	66.83
12	African-Brown China.....	10	4	....	.....	9	10	.....	.....	6	9	.....	....	.....	......	.....
"	" "	9	10	......	......	9	1	....	. .	6	5	.....	.....	....	......	.....
"	" "	10	12	......	....	10	3	......	....	6	13	......	.....	.....	....	.....
"	" "	10	8	.....	....	9	14	.....	.....	6	6	.. ..	.....	.....	.....	.....
"	" "	10	13	.....	....	10	13	......	......	8	3	. .	...	......	..	.. ..
"	" "	12	0	63.94	10.69	11	3	60.75	10.12	7	13	42.06	7.01	95.01	69.23	65.81

[1] As sold in the market [2] Thoroughly cleaned, ready for cooking.

TABLE XLV.—*Continued.*

Yard.	Mating.	Live Weights.				Dressed[1] Weights.				Drawn[2] Weights.				Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
		Lbs.	Oz.	Total lbs.	Avg. lbs.	Lbs.	Oz.	Total lbs.	Avg. lbs.	Lbs.	Oz.	Total lbs.	Avg. lbs.			
13	White China-Embden	12	6	......	......	11	2	......	......	8	8	......	......	......	......	......
"	" "	12	12	25.18	12.56	12	6	23.50	11.75	9	7	17.94	8.97	93.91	76.34	71.38
14	Brown China-Toulouse ...	12	7	......	......	12	9	......	......	8	11	......	......	......	......	......
"	" " ...	17	12	......	......	17	0	......	......	11	14	......	......	......	......	......
"	" " ...	17	15	......	......	16	15	......	......	12	8	......	......	......	......	......
"	" " ...	16	14	......	......	15	12	......	......	11	8	......	......	......	......	......
"	" " ...	14	7	......	......	13	8	......	......	10	1	......	......	......	......	......
"	" " ...	12	0	......	......	11	10	......	......	8	0	......	......	......	......	......
"	" " ...	16	8	......	......	15	4	......	......	10	4	......	......	......	......	......
"	" " ...	17	9	......	......	17	0	......	......	12	4	......	......	......	......	......
"	" " ...	16	11	......	......	16	2	......	......	12	3	......	......	......	......	......
"	" " ...	17	0	159.19	15.91	16	14	152.63	15.26	13	1	109.75	10.97	95.87	71.90	68.94
15	Embden-African...... ...	18	9	......	......	17	12	......	......	12	3	......	......	......	......	......
"	" "	13	12	......	......	12	15	......	......	9	0	......	......	......	......	......
"	" "	12	5	44.63	14.87	11	7	42.13	14.04	9	2	30.31	10.10	94.39	71.94	67.91
	Average of all—38 geese from 12 matings													95.46	72.30	69.02

[1] As sold in the market. [2] Thoroughly cleaned, ready for cooking.

In table XLV there was less variation in the percentages. The greatest shrinkage was in the case of the African-Brown China cross, pen 12, where the drawn weight was 65.81 per cent. of the live weight, and the least shrinkage was in the case of a bird bred from the opposite mating, pen 5, whose drawn weight was 74.43 per cent. of its live weight. The average for 38 geese, from 12 matings, was 69.02 per cent., showing a loss between live and drawn weight of 30.98 per cent. The average loss in killing and picking was 4.54 per cent.

Thirteen goslings, dressed December 7th and exhibited at the show of the Rhode Island Poultry Association, at Westerly, were sent to Prof. H. C. Bumpus, of Brown University, for dissection. These birds represented thirteen of the principal crosses raised during the season. Prof. Bumpus kindly dissected these birds, separated skin and skin-fat, flesh, bones, and offal, and obtained the separate weights in each instance. The following table has been compiled from the figures kindly furnished by him. It gives the live, dressed, and drawn weight of each bird, with the per cent. of dressed to live weight, and of drawn to dressed weight; the per cent. of lean meat, including the liver, heart, and gizzard (the latter cleaned); the per cent. of skin and skin-fat; the per cent. of bones; the per cent. of "loss by drawing, including the head, feet, wings, and intestines;" the per cent. of loss by dissection, represented by grease and fluids, but largely grease; the per cent. of "loss by dressing, including feathers, blood, etc."

The percentages of the various parts of the bird are based upon the live weight.

TABLE XLVI.—*Showing, in Addition to the Live, Dressed and Drawn Weights, and the Percentage of Dressed to Live Weight and of Drawn to Dressed Weight, the Weights of Solid Meat, Skin and Fat, Bones, Offal and Feathers, Blood, &c., with the Percentage of Each Part Compared with the Live Weight, for Each of Thirteen Cross-bred Geese from Different Matings. All Weights are in Ounces.*

Yard No.	Mating.	Live weight, ounces.	Dressed wgt., ounces.	Dressed weight. Per cent. of live weight.	Drawn wgt. includes gizzard, liver, skin, skin fat and fat of body cavity. Oz.	Drawn weight. Per cent. of dressed wgt.	Solid meat exclusive of fat and bone. Includes liver, heart and gizzard, cleaned.		Skin and skin fat.		Bones.		Loss by drawing. Head, feet, wings and intestines.		Loss by grease & other fluids.		Loss by dressing. Feathers, blood, etc.		Total.
							Ozs.	%	Ozs.	%	Ozs.	%	Ozs.	%	Ozs.	%	Ozs.	%	%
1	Toulouse-African	223	212	95.06	161	72.19	76	34.0	45	20.1	10	4.4	51	22.8	30	13.4	11	4.9	99.6
2	Embden-Brown China..	167	157	94.01	118	70.65	63	37.7	24	14.3	9	5.3	39	23.3	22	13.1	10	6.0	99.7
3	Embden-Toulouse......	268	245	91.41	187	76.32	87	32.4	58	21.6	11	4.1	58	21.6	31	11.5	23	8.5	99.7
4	African-Toulouse	254	236	92.91	182	77.11	96	37.8	38	14.9	16	6.3	54	21.2	32	12.6	18	7.1	99.9
5	Brown China-African..	169	164	97.04	126	76.82	64	37.8	30	17.7	11	6.5	38	22.4	21	12.4	5	2.9	99.7
8	African-Embden........	254	227	89.37	169	77.44	86	33.8	34	13.3	15	5.9	58	22.8	34	13.3	27	10.6	99.7
9	Brown China-Embden..	204	187	91.66	145	77.54	77	37.7	30	14.7	14	6.8	42	20.5	24	11.7	17	8.3	99.7
10	Embden-White China..	187	178	95.18	137	76.96	69	36.8	32	17.1	11	5.8	41	21.9	25	13.3	9	4.8	99.7
11	Toulouse-Brown China	173	159	91.90	120	75.47	59	34.1	28	16.1	11	6.3	39	22.5	22	12.7	14	8.0	99.7
12	African-Brown China..	173*	158	91.32	120	75.94	59	34.1	24	13.8	11	6.3	38	21.9	26	15.0	15	8.6	99.7
13	White China-Embden..	175	160	91.42	120	75.00	67	38.2	16	9.1	11	6.2	40	22.8	26	14.8	15	8.5	99.6
14	Brown China-Toulouse.	262	244	93.12	187	76.63	91	34.7	48	18.3	12	4.5	57	21.7	36	13.7	18	6.8	99.7
15	Embden-African........	263	248	94.29	185	74.59	95	36.1	37	14.0	19	7.2	63	23.9	34	12.9	15	5.7	99.8

* Recorded live weight of this bird was 182 ounces, which was evidently an error. We therefore adopt for these calculations the weight of No. 11, as the dressed and drawn weights of the two so nearly correspond.

The above figures are of considerable interest, as showing the weight of different portions of the carcass of the goose. The percentages of dressed and drawn weights may be compared with those of a larger number of individuals given in the previous tables.

The per cent. of the lean meat varies from 32.4 in the case of the Embden-Toulouse, No. 3, to 38.2 for the White China-Embden, No. 13. The per cent. of skin and skin-fat was largest in the case of the No. 3, 21.6 per cent, and smallest in that of No. 13, 9.1 per cent, showing the former to have been very well fattened, while the latter bird was the poorest among the number. The per cent. of bone was smallest in the case of No. 3, the next lowest being the Toulouse-African, No. 1. The bones vary in weight from 9 ounces, in the case of the Embden-Brown China cross, to 19 ounces, in the Embden-African cross, No. 15; in the latter case the bones represented 7.2 per cent. of the live weight.

The head, feet, wings, and intestines, with the contents of the gizzard, representing the shrinkage in drawing, varied from 20.5 per cent. of the live weight in the case of the No. 9, Brown China-Embden cross, to 23.9 per cent. in the Embden-African cross. The per cent. of offal was remarkably uniform, there being a variation of only 3.4 per cent.

The column headed "loss by grease and other fluids," was largely the loss by dissection, and in the ordinary processes of drawing and cooking would not represent waste. "The loss by dressing, of blood, feathers, etc.," varied from 4.9 per cent. to 10.6 per cent. in the cases of Nos. 1 and 8, respectively. This loss varies, more or less in proportion to the amount of blood drawn at the time of killing. Some birds bleed more freely than others, and hence lose more weight, and the fact that geese at all seasons of the year have the bodily heat extracted with ice water, may in some instances influence the dressed weight.

The Influence of one White Parent in Cross Breeding Geese.—Attention has been called to the fact that white or pied geese usually require less labor in picking, on account of freedom from black

pin-feathers, and are often preferred in the market on account of the better color of the skin and flesh. The importance attached to a yellow bill and legs by certain classes has also been mentioned, and, as these points have an important bearing upon practical goose breeding, it is of interest to note the effect of one white parent upon the color of the crossbred progeny. The two white breeds are Embden and White China, and both have flesh-colored, orange or yellow bills. From the tables of green and mature geese dressed for market, in 1896 and 1897, we collate the following:

Embden Crosses.

Matings.	Number of white or pied goslings.	Per cent. of same.	Number of goslings of solid dark color.	Per cent. of same.
White male and dark females.				
Embden-African	29	87.87	4	12.13
Embden-Toulouse	18	90.00	2	10.00
Embden-Brown China	18	94.73	1	5.27
Dark colored male and white females.				
African-Embden	9[1]	40.90	13[2]	59.10
Toulouse-Embden	4	66.66	2[3]	33.33
Brown China-Embden	12	92.30	1	7.70

[1] One had mottled bill.

[2] Six had yellow, and three mottled bills.

[3] Had yellow bills.

White China Crosses.

MATINGS.	Number of white or pied goslings with yellow bills.	Per cent. of same.	Number of goslings of solid dark color and black bills.	Per cent. of same.
White male and dark females.				
White China–Toulouse..	2	100.00	0	.....
White China–Brown China............	0	.....	3[1]	100.00
Dark colored male and white females.				
Toulouse–White China........	1	50.00	1[2]	50.00
African–White China...............	5	62.50	3	37.50
Brown China–White China............	0	......	1[3]	100.00

From the above figures we find that Embdem ganders mated with dark colored females produced 72 goslings, of which 65, or 90.27 per cent., were white or pied, with yellow bills and legs, and only 7, or 9.73 per cent., were solid dark color, with black bills. The advantage of such crosses is very evident, especially when it is recalled that they rank first, or among the first for quality, and the Embden-African cross is hardly excelled in size and rapidity of growth.

In the crosses produced by mating dark colored ganders with Embden geese we have the notes for 41 goslings, of which number 25, or 60.97 per cent., were white or pied, and with one exception had yellow bills, and 16, or 39.03 per cent., were solid dark colors, but 9 had yellow bills, 3 mottled, and 3 black bills. It is evident that the advantage of color is strongly on the side of mating the Embden male with dark females. The figures also indicate that more goslings are produced from such matings than from the opposite.

[1] One black, one mottled, and one yellow bill.

[2] Yellow bill.

[3] Mottled bill.

The White China crosses were very unproductive, and consequently we have only a limited number of observations. The progeny appears about equally divided between white or pied and dark colored birds. When the White China male was crossed with dark females, 40 per cent. of the progeny was white or pied, and 60 per cent. a solid dark color. The 2 white birds belonged to the Toulouse mating, and the dark birds to the Brown China mating. When dark males were mated with White China females, 54.54 per cent. of the progeny was white or pied, and 45.46 per cent. dark colored. The White China geese do not appear to have the prepotent power to fix their white color upon their offspring possessed by the Embdens.

THE INFLUENCE OF TOULOUSE BLOOD IN THE PRODUCTION OF GOSLINGS WITH YELLOW BILLS.

Toulouse geese have a bright orange colored bill and orange or yellow legs, and in the market, therefore, have whatever advantage that point gives over goslings from other dark breeds which have black bills.

Toulouse Matings.

(Plumage of progeny drab or darker colors.)

MATINGS.	Bills yellow or yellow mottled with greenish yellow or black.	Per cent. of same.	Bills black.	Per cent. of same.
Toulouse males.				
Toulouse–African	8	80.00	2	20.00
Toulouse–Brown China	24[1]	96.00	1	4.00
Toulouse females.				
African–Toulouse	17[1]	100.00	0	.....
Brown China–Toulouse	20	95.23	1	4.77

[1] Fifteen had yellow bills.

Where Toulouse ganders were used for one parent, the geese being dark colored with black bills, out of 35 goslings produced 32 had yellow bills or yellow, mottled with olive or darker colored spots, and only 3 had solid black bills; in other words, 91.42 per cent. of the crosses had yellow, and only 8.58 per cent. black bills.

When Toulouse females were mated to dark ganders with black bills, out of 38 goslings only 1 had a bill entirely black; that is, 97.57 per cent. had yellow or mottled bills, and only 2.43 per cent. black bills.

MARKET QUOTATIONS IN 1897.

Messrs. Knapp & Van Nostrand, No. 241 and 243 Washington street, New York, kindly furnished the following quotation of prices paid for Rhode Island geese during the season of 1897:

The first lot of green geese was received May 20, and the price paid was .... 25 cents per pound.

Prices change as follows:	June 4,	paid	24	"	"	"
	" 9,	"	22	"	"	"
	" 12,	"	21	"	"	"
	" 16,	"	20	"	"	"
	" 22-29,	"	18	"	"	"
	July 9-14,	"	16	"	"	"
	July 16 to Aug. 24,	"	15	"	"	"
	Aug. 31 to Oct. 22,	"	14	"	"	"
Fancy stock to freeze—						
	Oct. 23 to Dec. 3,	"	14½	"	"	"

Messrs. W. H. Rudd, Son & Co., No. 40 North street, Boston, Mass., under date of February 16th, 1898, say: "Green geese began to arrive last season the early part of June, and we paid 25 cents per pound for the first lots. Later shipments, the latter part of June, were 20 cents, and in July the price eased off to 16 cents, ranging from 13 to 15 cents the balance of the season, according to quality of stock. We paid 14 cents for Canadian geese, fattened in Rhode Island, during the fall months. We froze up quite a large stock for use through the winter at that figure. The supply

of these is about exhausted at the present time, and little stock arriving now except ordinary western geese, which range from 8 to 11 cents per pound according to quality, the majority being rather poor stock. The better class of hotels running upon the European plan take geese from the bill of fare after this time, and do not put them on again until the middle of June."

SUMMARY.

The date of the domestication of the goose is hidden in the dimness of pre-historic times. Ancient writings reveal the goose as one of man's domestic animals, valued for the flesh and feathers supplied by it for his food and comfort. Since the fourth century, quills from its powerful wings have furnished instruments for writing, valuable and indispensable, until in modern times supplanted by their imitation, the steel pen.

Two common varieties of domestic geese, Embden and Toulouse, are without doubt descended from the wild "Graylag goose," (*Anser ferus*) of England and the continent. Two other breeds, Brown China and White China, are derived from an Asiatic species known as *Anser cygnoides*, and it is quite possible that the African goose may have descended from the same original type.

All wild species are monogamous, including the Canadian goose (*Bernicla Canadensis*), in domestication. Domestic geese in general are polygamous to the extent of mating with two to four females. *Geese have* a strong attachment to the place or locality constituting their home, and removal just prior to or during the breeding season usually has a very injurious effect upon the egg yield and the fertility of the eggs.

Ganders and geese are much attached to their mates and seldom prove unfaithful. Mismating and remating are often unsuccessful unless old mates are separated beyond sight and hearing of each other.

Geese live to a great age, and females are reliable and productive breeders for many years, but ganders of the domestic varieties

are usually unreliable after seven to nine years. Canada ganders can be profitably kept for twenty-five or more years.

Geese only one year old are not mature as breeders. The females lay a less number of eggs, of smaller size, and a greater proportion is usually infertile than is generally the case with females two or three years old.

Geese are naturally timid, watchful, and easily frightened, but the ganders, during the breeding season, and in defense of their young, are bold and courageous to a remarkable degree. They have many peculiarities which the breeder who would be successful should carefully study. They should be gently and kindly treated at all times.

Water for bathing purposes is highly desirable during the breeding season in order to insure a large per cent. of fertile eggs.

The goose is naturally a grazing animal. The bill is provided with sharp, interlocking, serrated edges, designed to easily cut and divide vegetable tissues, and the tongue at the tip is covered with hard, hair-like projections, pointing toward the throat, which serve to quickly and surely convey the bits of grass and leaves into the throat. See figure 9. Goslings make the greater part of their growth upon grasses or fodder plants, and can thus be more economically produced than poultry which requires to be almost exclusively grain fed.

In cold climates shelter during severe weather should be provided, to guard against frozen feet. During the breeding season the liberal feeding of a nutritious ration, not too fattening, has a beneficial effect upon the egg production. Green food, ground oyster shells, grit and charcoal should be provided.

Two or three litters of eggs may be secured by "breaking up" the goose by shutting her in a pen for a few days when broody, and setting the eggs under hens. A good sized hen will cover 5 eggs, a goose from 9 to 13 eggs. Twenty-eight to thirty days' incubation is required for hatching.

Little goslings require no food until 24 hours old. They should

always have water for drinking. They should have short tender grass, soaked cracked corn, or dough of oatmeal and corn meal, which may be mixed with sweet milk, and access to sharp sand saturated with water. Grass should form their principal food. They should be protected from extreme heat of the sun, from showers or storms, from damp bedding or wet floors at night, and should not be crowded or huddled together.

The fattening of green geese should begin when the flight feathers of the wings have grown sufficiently to reach the tail. They should then be penned up in moderately close quarters upon gravelly or sandy soil which will not be muddy in wet weather; provided with water for drinking, and fed twice daily upon scalded dough composed of four parts Indian meal and one part best ground beef scraps, slightly salted and fed cold. At noon they should have whole corn. About 17 to 20 days is usually required. Geese fatten most rapidly in cool weather, and in November are killed and placed in cold storage for the winter trade.

Green geese are killed by a cut in the upper and back part of the mouth, carefully picked, leaving the feathers upon the wings beyond the first joint and upon the lower two-thirds of the neck. The wings are tied tightly against the sides, the bodily heat removed by keeping in ice water until ready to pack in ice for shipment to market. The price realized varies from 25 cents per pound June 1st, to about 14 cents during August, September and October.

The cross breeding of geese is a very practical question, because of the long life and permanency of the breeding stock. By mating Embden ganders with African, Toulouse or Brown China geese, hardy, vigorous, quick growing goslings are secured, having all the good points of the dark breeds, combined in a large majority of cases with white or pied plumage, and a yellow bill—birds which dress easily and command the highest price in the market.

Mongrel geese are best produced by mating a Canada gander with an African or Toulouse goose. Secluded quarters, natural water supply for bathing, sense of liberty and freedom from dis-

turbance by other geese or animals, are rather essential to successful breeding. The gander must be two, three, or more years old, and mate with but one goose which should have already proved herself a good breeder. Hence, stock for breeding mongrels is expensive. Mongrels are usually fattened during the cool weather of autumn, and dressed for the holiday trade, when they bring from fifty to one hundred per cent. more than ordinary domestic geese.

The feathers of geese, though not so valuable as formerly, are of sufficient worth to about offset the price paid for picking and preparing for market. Picking live geese is now seldom practiced by goose breeders in this State. Young geese intended for market in the autumn, should never be picked alive during the summer, as it interferes with their growth and injures the appearance when finally killed and dressed for market.

According to the R. I. Census for 1895, each breeding goose (male or female) produced in goslings and feathers an average return of $6.76, which represents 371.42 per cent. upon the value of the breeding stock.

According to the R. I. Census for 1885, the average product per sheep in wool and lambs was $2.51, while the same year the average product per goose was $2.72, or twenty-one cents more for each breeding goose kept than for each breeding sheep.

One goose breeder in Little Compton[1] as the average result of eight (8) years' work, from 1890 to 1897 inclusive, secured a return of $7.48 each upon a flock of breeding geese averaging between 62 and 63 in number.

PURE BREEDS.

Five pure breeds have been kept and bred for two years,[2] confined during the breeding season in yards about 60x60 feet in size, and supplied with water in sunken half barrel tubs.

The average egg yields for two years have been: White Chinas,

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[1] P. H. Wilbur.

[2] In addition to three years' work previously reported by Samuel Cushman in the Annua Report for 1895.

31.9 eggs; Brown Chinas, 31 eggs; Toulouse, 26 eggs; Embdens, 18.6 eggs; and Africans, 16.5 eggs.

The average weight of eggs has been: Africans, 6.699 ounces each; Embdens, 6.567 ounces; Toulouse, 6.3 ounces; White China, 5.522 ounces; and Brown China, 5.445 ounces each.

The percentage of goslings from the *total number of eggs set* from the *pure bred matings* was: White China, 3.22 per cent.; Brown China, 21.05 per cent.; both in 1896, no matings were made in 1897. Toulouse, 1897, 40 per cent. Africans, 1896, 51.21 per cent.; 1897, 22.22 per cent.; average 36.715 per cent. Embdens, 1896, 4.54 per cent.; 1897, 54.11 per cent.; average 29.325 per cent.

The percentage of goslings from the *total number of eggs set* including all the matings made and the figures for two years was: African females, 36.24; males, 39.94; *average, 38.09* per cent. Toulouse females, 34.86; males, 29.59; *average, 32.22* per cent. Embden females, 29.63; males, 31.29; *average, 30.46* per cent. Brown China females, 33.71, males, 23.44; *average, 28.57* per cent. White China females, 11.05; males, 10.55 *average, 10.80* per cent.

The average daily growth of pure bred goslings in 1896 was as follows, for 69 to 71 days old:[1] Brown Chinas, 1.36 ounces; White Chinas, 1.585 ounces and Africans, 2.004 ounces. In 1897, at 71 to 74 days old, the average daily growth was: Toulouse, 2.001 ounces; Embden, 2.020 ounces; and African, 2.280 ounces per day. The average weights at above ages were: Brown China, 5.95 lbs.; White China, 6.94 lbs.; African, '96, 8.78 lbs., '97, 10.24 lbs.; Toulouse, '97, 9.08 lbs.; and Embden, 9.13 lbs. each. The heaviest young geese dressed in the fall months weighed as follows: Brown China, 15.50 pounds live weight; African, 17 pounds; and Embden, 19.44 pounds.

CROSSES.

Nineteen matings for the production of cross-bred geese were made during 1896 and 1897. Goslings were hatched from all these matings, but in some instances very few in number. So far

[1] The weight of the goslings when hatched is included.

as possible, photographs were taken of representatives of the various crosses, both alive and dressed, from which the accompanying cuts are reproduced.

In taking the photographs of dressed geese the camera was kept in exactly the same position in relation to the bird in each case, so that the cuts give an accurate idea of the relative size and shape of the representatives of the different crosses. So far as possible this was also done in photographing the live geese, but, of necessity, with less accuracy.

Embden-African Cross, yard 15 (Fig. 12).—Previous to 1896 this cross had proved one of the most desirable for rapidity of growth and size attained. In 1896 a fine Embden gander from imported stock was mated with choice African geese, in yard 15, and the progeny proved the best cross-bred birds obtained. The highest per cent. of goslings from eggs set—75 per cent.—was obtained from this mating, and they were vigorous and hardy. At about 5 weeks old they were exceeded in average weight by the progeny of 7 other matings. At 8 weeks they gave the 5th highest average weight. At 10 weeks they headed the list, averaging 9.83 pounds each, having made a daily growth of 2.24 ounces. As green geese, the average of 9 birds in the first hatch was 14.03 pounds live weight, and 13.47 pounds dressed. As all the progeny of this mating was white or pied, with yellow bills and legs, they picked easily, and were pronounced No. 1 in both Boston and New York markets. Three of these cross-breds, dressed in December and February, averaged 17.43 pounds alive, and 16.37 pounds dressed. They exceeded in average weight, as green geese and mature birds, all pure breeds or crosses in 1896. During the summer the gander used in this mating sickened and died, and in 1897 this cross was bred from yards 1 and 15, and the best ganders available were used, although not as heavy as the one used in 1896. The per cent. of goslings secured from eggs set was only 28—but, as before, they were thrifty and strong. Out of 17 green goslings of this cross only 1 was a dark colored bird with a black bill; all the others were either white or pied and had

yellow bills. The average weights were less than those given above. At 5 weeks old they ranked seventh in average weight; at 8 weeks they held the second place for greatest average weight, and at 10 weeks they were exceeded by goslings from 7 other matings. The average live weight of one hatch, when killed as green geese, was 11.51 pounds, and of the other, 11.09 pounds. One shipment was classed as "second best lot," the first choice being an Embden-White China cross, and the other was classed No. 1. Figure 12 shows the general appearance of the birds of this cross. Another cut of birds of this cross is given in the Annual Report for 1895. The reverse of this mating produced the

African-Embden Cross, yard 8 (Figs. 13 and 14).—This cross partakes more strongly of the type and color of the African goose. The progeny are strong and vigorous, but more than fifty per cent. were dark in color, and a majority of those had black bills, like the African. This single point makes the use of the Embden-African cross preferable to this. In rapidity of growth and average weight there is little difference between the two crosses. At eight weeks old in both years this cross has headed the list for greatest average weight. The average daily growth in 1896, to that age, was 2.488 ounces. At ten weeks old this cross ranked second in average weight in 1896, and third in 1897. As green geese the various shipments averaged from 10.36 to 11.68 pounds live weight, and the heaviest specimen weighed 12.25 pounds dressed. Individual birds from this cross were pronounced equal to the best, but the general grade was about number two, probably more on account of the dark feathers and black bills than of inferiority in shape or size. As mature birds they averaged 15.45 pounds alive, and 14.50 pounds dressed. Both these crosses shrink in dressing a little more than some others. The figures for both are as follows:

	Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
Embden-African cross	94.39	71.94	67.91
African-Embden cross	94 08	71.85	67.61

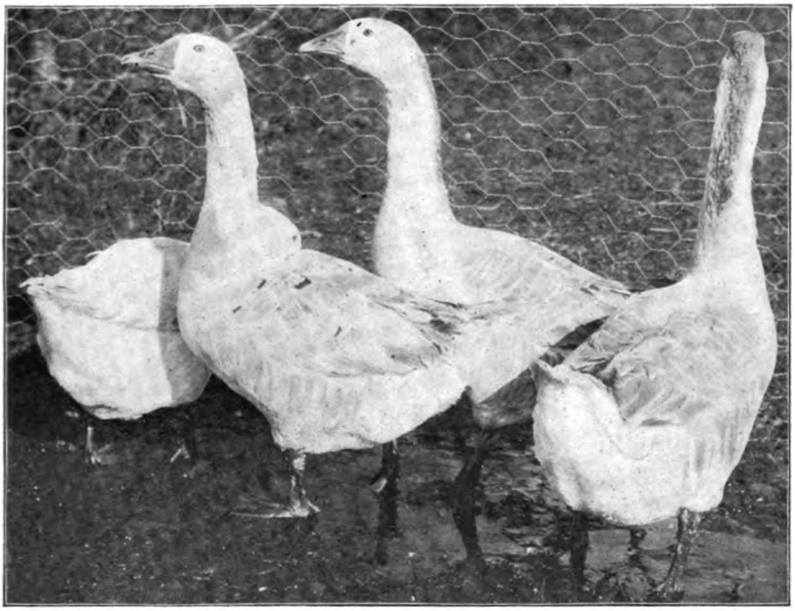

FIG. 12. Embden-African Cross. Yard 15.

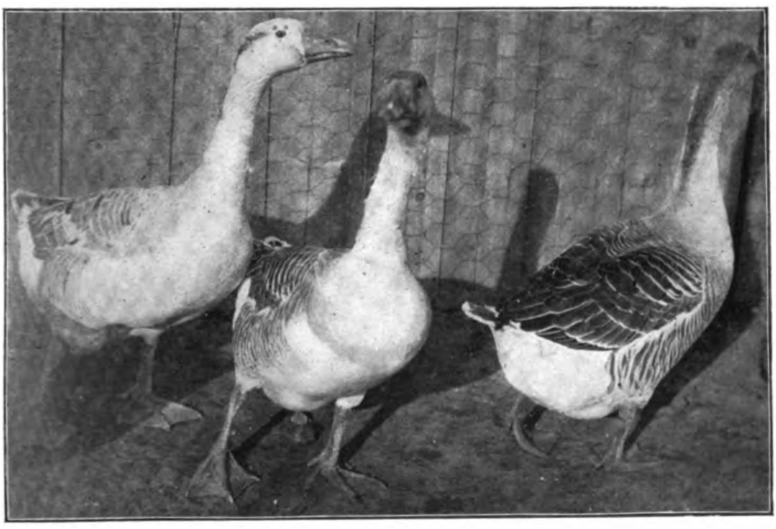

FIG. 13. African-Embden Cross. Yard 8.

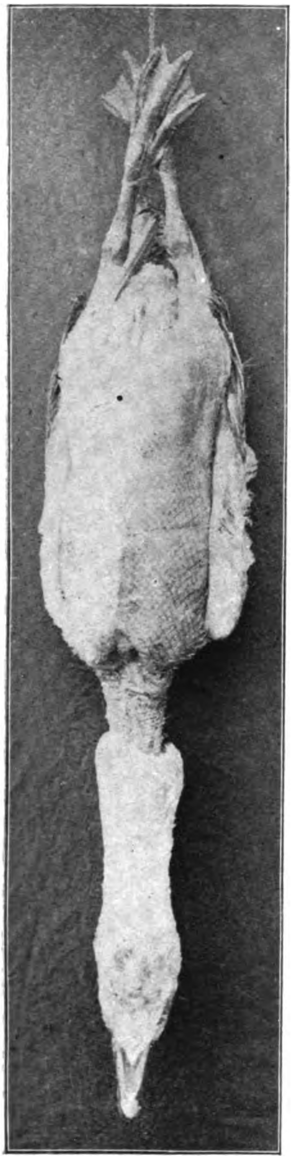

Fig. 14.
African-Embden Cross.
Yard 8.

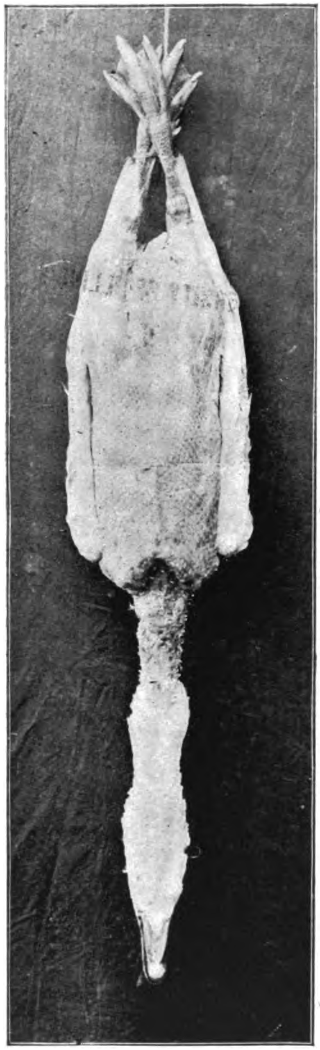

Fig. 15.
Embden-Brown China Cross.
Yard 2.

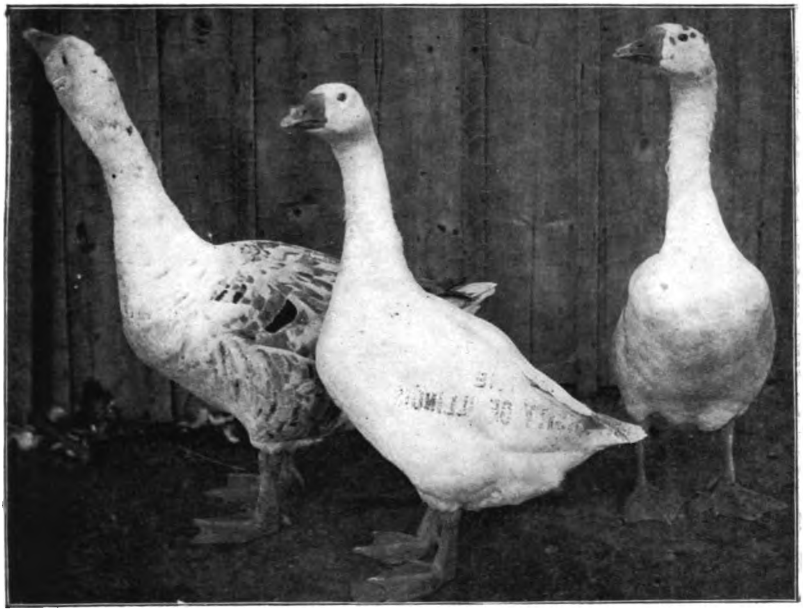

Fig 16. Embden-Brown China Cross Yard 2.

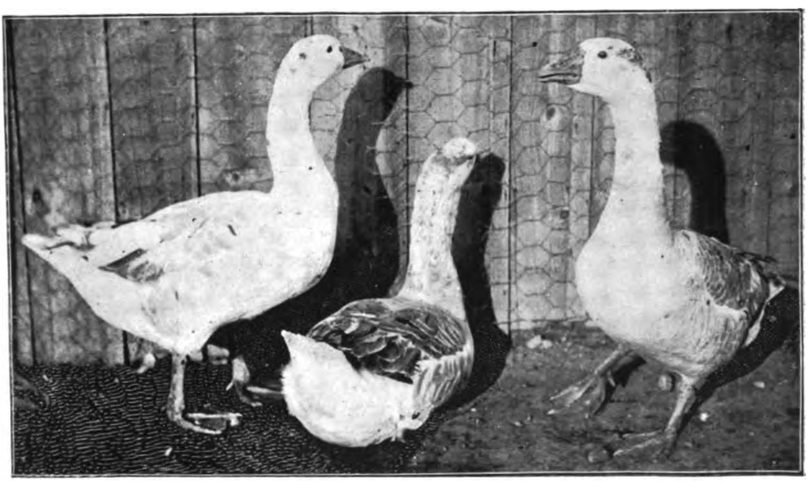

Fig. 17. Brown China-Embden Cross. Yard 9.

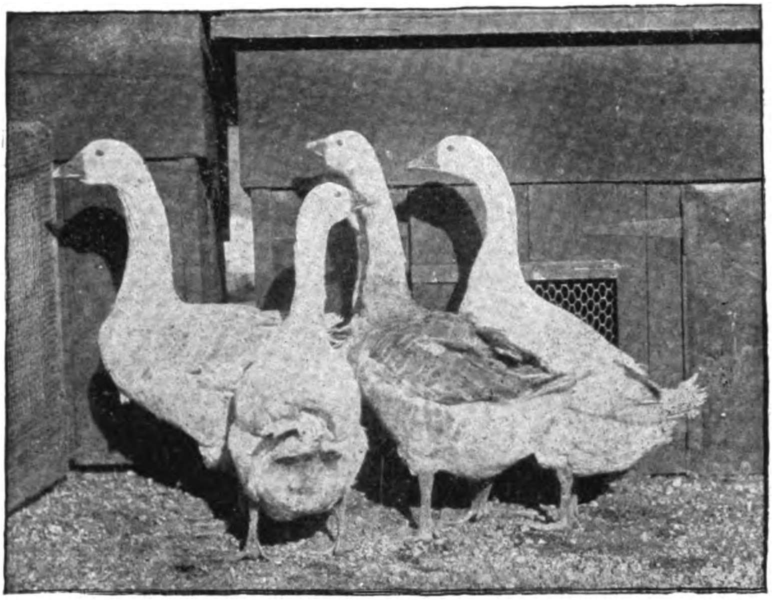

Fig. 18. Embden-Toulouse Cross. Yard 3, 1895.

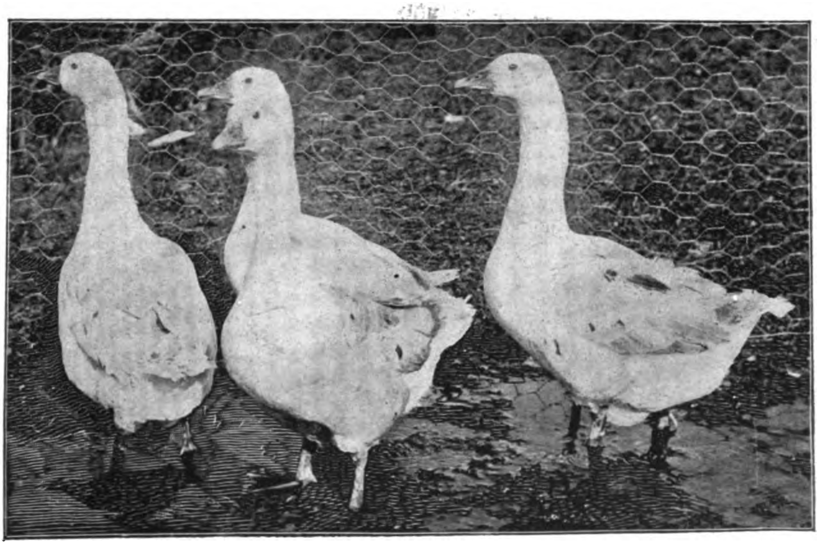

Fig. 19. Embden-Toulouse Cross. Yard 3, 1896.

Embden-Brown China Cross, yard 2, (Figs. 15 and 16).—As the Brown China strongly resembles the African except in size, we would naturally expect this cross to resemble the first one described, and the photographs show a great similarity of coloring, (Compare Figs. 16 and 12.) This cross was productive, the per cent. of goslings to eggs set being one year 34.14, and the next 46.62 per cent. The goslings grew well and ranked about average of the crosses in size. At 10 weeks old they averaged alive, one year, 8.13 pounds, and the next 8.95 pounds. The greatest average daily growth to that age was, for this cross, 1.975 ounces. Sold as green geese they averaged about 10.50 pounds live weight; 94.73 per cent. of this cross have been white or pied, with yellow bills. They have been classed in the market, with the exception of one bird, as fair to No. 1. Mature birds have averaged 12.33 pounds alive, and 11.47 pounds dressed. One bird from this cross weighed alive 16 pounds, and dressed 15.06. The reverse mating was the

Brown China-Embden Cross, yard 9 (Fig. 17).—This cross strongly resembled the Embden, and showed much less influence in the matter of color from the Brown China gander than was shown in the case of the African-Embden cross, Fig. 13; 92.30 per cent. of these goslings were white or pied, and had yellow bills. This is a less desirable cross to make than the reverse, just described, because Brown China females lay some 30 per cent. more eggs, and from our matings they hatched very much better than those from this cross. The birds from this cross are perhaps a little larger average size than from yard 2, but did not prove so satisfactory in the market, being classed fair to No. 4. The shrinkage in dressing on these two crosses was as follows:

	Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
Embden-Brown China cross	92.81	75.28	69.85
Brown China-Embden cross	97.84	72.10	70.55

Embden-Toulouse Cross, yard 3 (Figs. 18 and 19). This cross proved as fertile as the average under our conditions, hatching

37.03 per cent. of the eggs set one year, and 22 per cent. the next. At 5 weeks old in 1896, they were second in average weight. At 8 weeks old they ranked seventh, and averaged the same as the pure Africans. At 10 weeks old they tied with the Africans for fifth place. Their average weight was 8.78 pounds, equal to a daily growth of 2.004 ounces. Fattened as green geese, they weighed from 10 to 13 pounds, and were classed from "good stock" to No. 1. As mature birds they weighed from 12.50 to 17.13 pounds each, averaging 14.68 pounds alive, and 13.89 pounds dressed. All the birds bred in 1896 were white or pied with yellow bills, but in 1897, two of the progeny were the color and shape of Toulouse. Altogether, 90 per cent. of the goslings from this cross were white or pied. This cross did not average quite as large in 1897 as in 1896.

Toulouse-Embden Cross, yard 7.—Only 4 goslings were hatched from this mating in 1896, equal to 20 per cent. of the eggs set, and unfortunately, they were among the goslings killed by the dogs. At 5 weeks old their average weight was next to that of the Brown China pure, which was lowest of all. Their average weight was only 2.29 pounds when the pure Embdens averaged 4.13 pounds. In 1897 there were two Embden females in this yard, but only 15 eggs were laid, from which 7 goslings were hatched, or 46.66 per cent. At 5 weeks old they averaged 3.19 pounds, and ranked seventh in average weight. At 8 weeks old they were eighth in average weight, and at 10 weeks they averaged 10.03 pounds each, making a daily growth of 2.177 ounces, and held the second place for average weight. As green geese they averaged alive 12.29 pounds, and dressed 11.86 pounds. Two of the birds were dark in color, like the Toulouse, and the others white or pied, but all had yellow bills. They were classed in the market as "fair" and "No. 1."

Toulouse-Brown China Cross, yard 11 (Figs. 20 and 22).—This cross produced 37.09 per cent. of goslings from the eggs set. The goslings were strong and hardy, bearing rather more resemblance to the Toulouse than the Brown China type. At 5 and 8 weeks

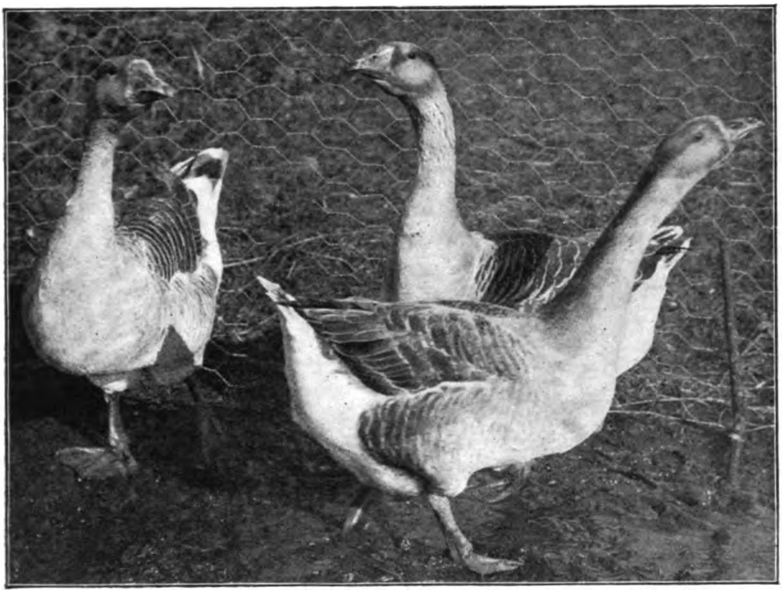

Fig. 20. Toulouse-Brown China Cross. Yard 11, 1896.

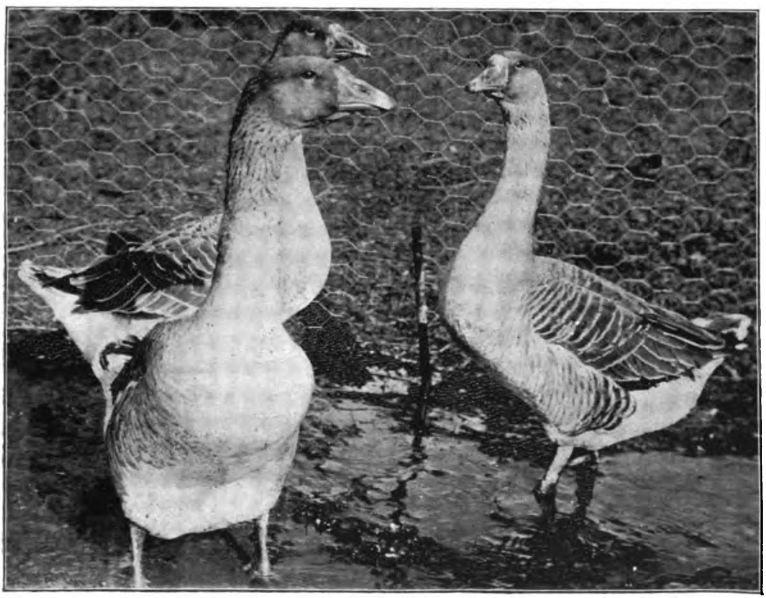

Fig. 21. Brown China-Toulouse Cross. Yard 14.

Fig. 22.
Toulouse-Brown China Cross.
Yard 11. 1896.

Fig. 23.
Brown China-Toulouse Cross.
(Too many feathers left on neck.)
Yard 14.

old they were below the average of the crosses in weight. At 10 weeks old they averaged 7.98 pounds, and the goslings from 10 matings exceeded them in weight. At about 5 months old they averaged 11.12 pounds live weight, while their opposite cross, yard 14, averaged 13.68, and the African-Embden cross averaged 14.22 pounds. As mature geese they averaged 12.07 pounds alive, and 11.31 pounds dressed. In the market one lot was classed as "No. 4" and "not recommended," and the other, all but one of which were Toulouse, colored birds, were commended as "fair to good stock." Only 4 per cent. of this cross was of decidedly Brown China type; 96 per cent. was of a lighter color, and had yellow or greenish yellow bills with black nails at the extremity, and black claws. The reverse mating produced a

Brown China-Toulouse Cross, yard 14 (Figs. 21 and 23).—In Fig. 23 the feathers should have been picked somewhat farther down the neck. The larger size of this cross, as compared with the preceding, is evident from Figs. 21 and 23. The influence of the Toulouse blood is very plainly shown in Fig. 21, and a little less distinctly in Fig. 20, by the curled or twilled feathers on the necks of the birds photographed. This was one of the most productive crosses, as Toulouse geese are good layers and Brown China ganders are active birds, insuring a good proportion of fertile eggs. In 1896 48.10 per cent. of eggs set produced goslings; but in 1897 only 25 per cent. was obtained. The goslings are very vigorous and hardy, and grow rapidly. At 5 weeks old this cross stood at the head of the list for average weight and greatest daily gain. At 8 weeks old they held the second place, the African-Embden cross holding the first; and at 10 weeks old they had dropped to fourth place. Embden-African (15), African-Embden (8) and African-Toulouse (4), crosses ranking above them in the order named. Their average weight at this time was 9.17 pounds, and their daily growth 2.097 ounces. In 1897 their average weight at about 10 weeks old was 8.98 pounds, and the daily growth 1.995 ounces. The average live weights of the lots of green geese shipped varied from 10.82 to 12.27 pounds alive, and dressed from

10.42 to 11.87 pounds. One lot was classed "fair" and "good stock;" another lot, "No. 2;" and another, "No. 2" and "No. 4." As mature birds they averaged alive 15.58 pounds, and dressed 14.68 pounds, in 1896. In 1897 the average weights were 15.31 pounds alive, and 14.50 pounds dressed. The heaviest bird dressed weighed alive 19.38 pounds, and dressed 18.38 pounds. Five birds out of 12, in table XX, weighed alive over 17 pounds each. Most of the birds follow the Toulouse type in size and color of plumage; 95.23 per cent. had yellow or greenish yellow bills usually, with black nails and claws. The shrinkage in dressing has been as follows for the two crosses:

	Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
Toulouse-Brown China	94.69	70.56	66.83
Brown China-Toulouse, 1896	95.87	71.90	68.94
" " 1897	94.70	69.37	65.05

African-Toulouse Cross, yard 4, in 1896 (Fig. 24).—This cross bears a strong resemblance to the one last described, but apparently the African blood had a greater prepotent power than that of the Brown China, and therefore the progeny have a greater tendency toward the African type than the Toulouse. The cross is prolific, the per cent. of goslings to eggs set being 53.84, and they come from the shell strong and active. At 5 weeks old they ranked fifth in average weight, and at 8 and 10 weeks old they held the third place. Their average weight at the latter age was 9.45 pounds, and average daily growth 2.15 ounces. As green geese the average live weight was 12.34 pounds, and 11.90 pounds dressed. They were classed "No. 4" in one market, and pronounced "good birds, but appearance against them," in the other. As mature geese they weighed 15.14 pounds average live weight, and 14.14 pounds dressed. The heaviest specimen weighed 18.81 pounds alive, and 17.88 pounds dressed. Some of these birds were rather hard to pick. All the progeny showed the influence of the Toulouse blood in the modified color of the bill, a green-

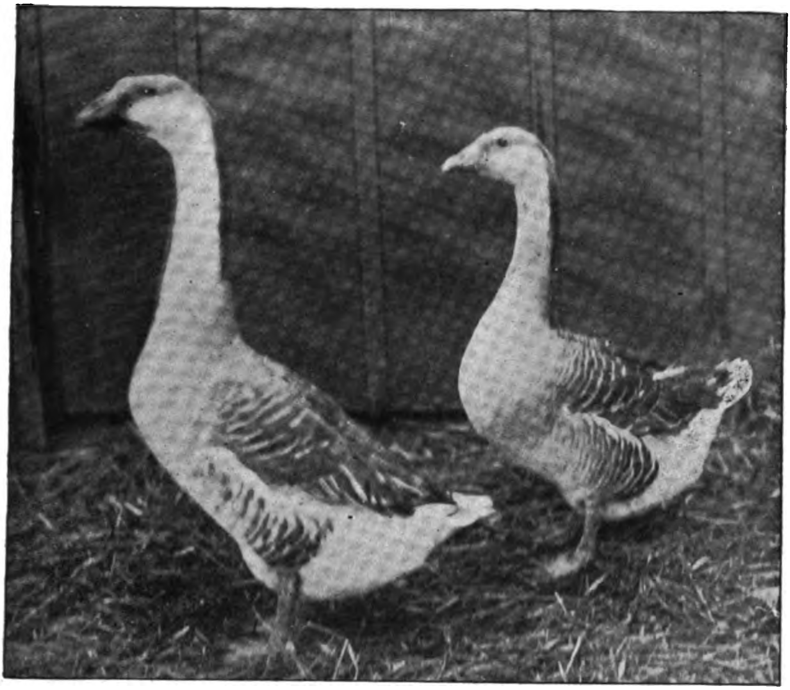

Fig. 24. African-Toulouse Cross. 1895.

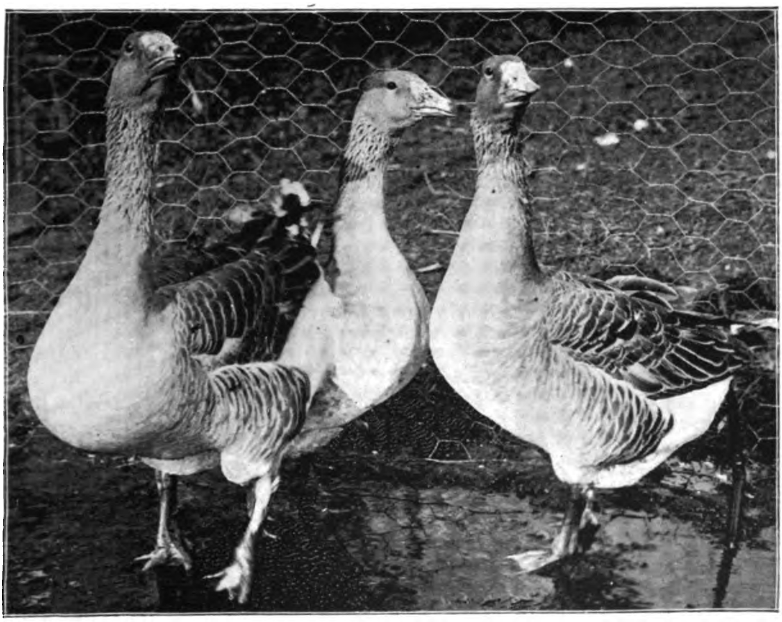

Fig. 25. Toulouse-African Cross. Yard 1.

Fig. 26.
Toulouse-African Cross.
Yard 4.
(Too many feathers left on neck.)

Fig. 27.
African-Brown China Cross.
Yard 12.
(Too many feathers left on neck.

ish yellow color, with black nail predominating. The reverse mating was for the production of the

Toulouse-African Cross, yard 1, 1896 (Figs. 25 and 26).—In the case of the bird illustrated in Fig. 26, the picker left too many feathers on the neck. They should have been removed a little farther down. This cross had a good deal of the Toulouse shape, and the twilled feathers on the neck, so characteristic of the Toulouse; but the dark stripe on the head and back of the neck, with a generally darker color, gave a strong resemblance to the Africans. The cross was a fairly prolific one, as 46.66 per cent. of the eggs set produced goslings. At 5 weeks old they held the eighth place for average weight, tieing for that position with the Embden-African cross. At 8 weeks old they held the fourth place and at 10 weeks old their average weight was 8.79 pounds, or just 2 ounces of growth per day. The progeny of six other matings exceeded their weight. As green geese they averaged 12.06 pounds alive, and 11.44 pounds dressed. They were classed "No. 3" in one market, and, with the birds from yard No. 4, as "good stock, but appearance is against them," in the other. As mature birds they averaged 15.50 pounds alive, and 14.91 pounds dressed. The shrinkage in dressing for the two crosses was as follows:

	Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
African-Toulouse cross	96.43	73.00	70.40
Toulouse-African cross	97.28	70.28	68.37

African-Brown China Cross, yard 12 (Figs. 27 and 28).—In this case, also, more feathers should have been removed from the neck in Fig. 27. This was the most prolific mating made in 1896; 56.59 per cent. of the eggs set produced goslings, and, while that percentage was exceeded in one instance, the large number of eggs laid in this instance gave more goslings than were raised from any other mating. At 5 weeks old these goslings ranked fourteenth in average weight. At 8 weeks old they ranked twelfth, in com-

pany with yard 22, which just equalled it in average weight, and at 10 weeks old their average weight was 7.51 pounds, and they were exceeded by the progeny from 11 other matings. The average live weight of one lot of green geese shipped was 10.03 pounds, and dressed weight 9.78 pounds; of another, 9.64 pounds alive, and 9.36 pounds dressed. As mature geese they averaged 10.91 pounds alive, and 10.13 pounds dressed. They did not give very good satisfaction in the market: the highest grading was "fair," and from that down to "No. 4." The heaviest bird dressed weighed only 12.88 pounds alive. The opposite mating produced the

Brown China-African Cross, yard 5 (Fig. 29).—This was one of the poorest crosses made. From the eggs set 25 per cent. of gosing were hatched. At 10 weeks old they averaged 7.47 pounds, which varied but a trifle from the average weight of the opposite cross at the same age. As green geese they averaged alive 9.06 pounds, and dressed 8.75 pounds. In the market they ranked with the poorest birds sent. As mature geese they weighed 11.35 pounds alive, and 10.78 pounds dressed. Both these crosses were very uniform in color and appearance, the Brown China-African cross having somewhat more of the characteristic carriage of the Brown China than the opposite cross, which had a greater resemblance to the African. There is little to be gained by crossing these two breeds. The pure bred African is superior to either cross. The record of shrinkage in dressing is as follows:

	Per cent. of dressed to live weight.	Per cent. of drawn to dressed weight.	Per cent. of drawn to live weight.
African-Brown China	95.01	69.23	65.81
Brown China-African	93.48	79.62	74.43

Embden-White China Cross, yard 10 (Figs. 30 and 32).—The eggs from this mating were very infertile: only 7.14 per cent. of those set hatched goslings in 1896, and in 1897 10.34 per cent. The first year at 10 weeks old they averaged 7.50 pounds each, which was .56 of a pound more than a pure White China weighed. One of

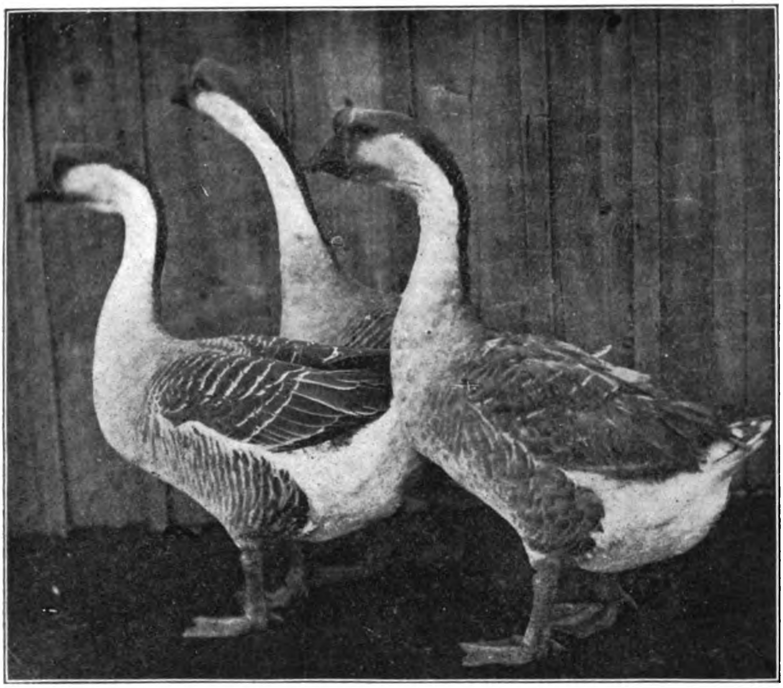

Fig. 28. African-Brown China Cross. Yard 12.

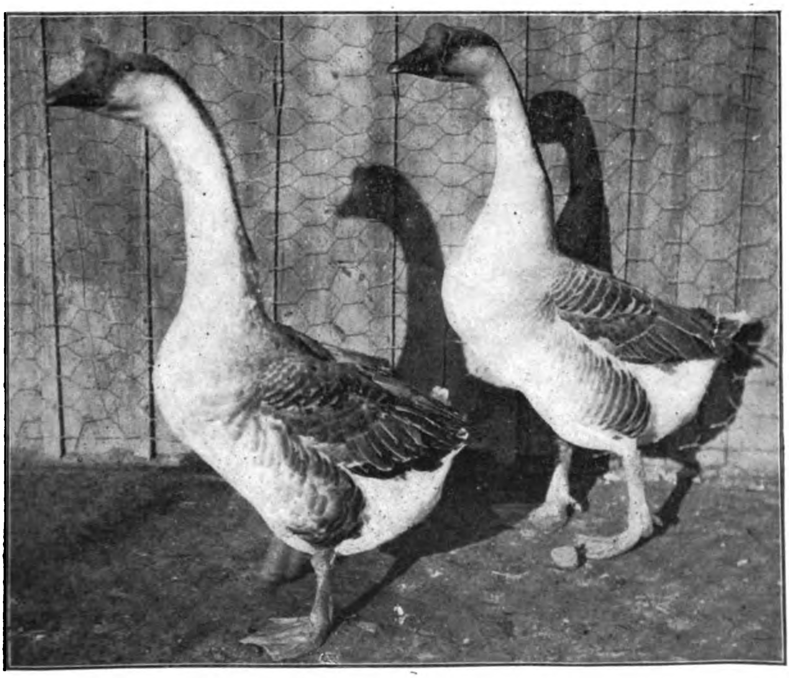

Fig 29. Brown China-African Cross. Yard 5.

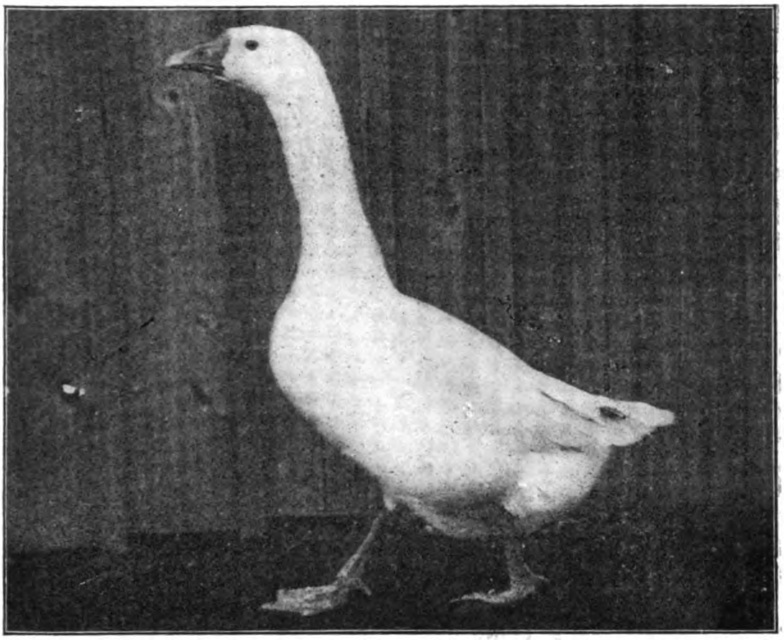

Fig. 30. Embden-White China Cross. Yard 10.

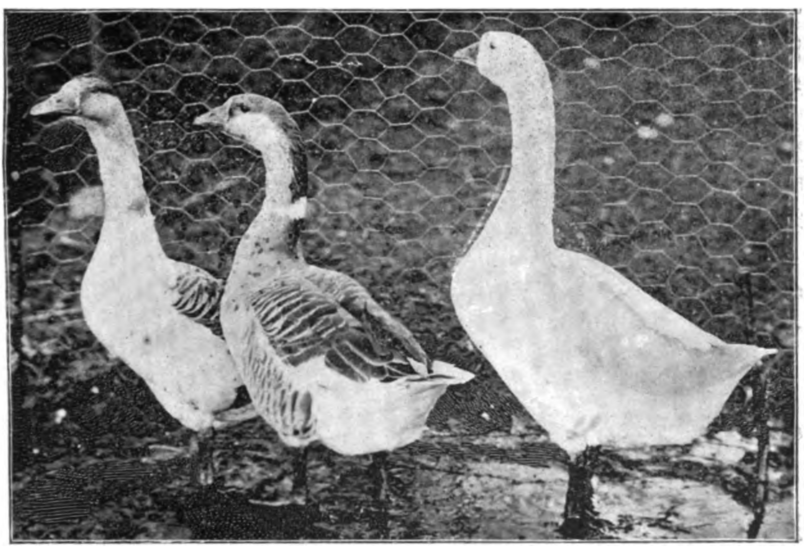

Fig. 31. White China-Embden Cross. Yard 13.

Fig. 32.
Embden-White China Cross.
Yard 10.

Fig. 33.
White China-Embden Cross.
Yard 13.

the two birds raised was sold as a green goose, and weighed 10.50 pounds alive, and 10.13 pounds dressed. It was classed as "below the usual grade received." In 1897, five birds of this cross were sold as green geese. At 10 weeks old they averaged 8.41 pounds, and when fattened and sold the average live weight was 10.50 pounds, and 9.77 pounds dressed. These birds were commended in the market as "the best shaped, plumpest, and in every way a little superior to the others." Three of the five birds in 1897 were pied, and the other two white, which was a little surprising, coming from a cross of two pure white breeds. It forcibly illustrates the fact that crossing breeds is almost certain to bring to the surface any digression from the fixed type previously made. There had doubtless been some faulty breeding at some time in the past among the ancestors of the stock used, and, therefore, crossing brought progeny with colored feathers. One mature goose of this cross weighed alive 11.69 pounds, and dressed 11.13 pounds.

White China-Embden Cross, yard 13 (Fig. 31).—This was the only White China mating in 1896 which produced anything like a reasonable number of fertile eggs. In this case the percentage of goslings from eggs set was 52.93, but only 17 eggs were laid by the goose. At 5 weeks old this cross ranked fourth in average weight. At eight weeks old they ranked fifth in average weight, and at 10 weeks averaged 7.45 pounds each, which was only fifth from the lowest average weight. In 1897, at 10 weeks old this cross averaged 8.75 pounds. The average weight of the green geese for the two years was 9.01 pounds alive, and 8.81 pounds dressed. One was pronounced a "good bird," and one "below usual grade received." As mature birds the average weight of eight specimens was 10.98 pounds alive, and 9.98 pounds dressed. Several birds of this cross were pied, one of them having colored feathers over the greater part of the body, as shown in Fig. 31. The Embden stock used in both the above crosses was a different strain in 1897 from that used in 1896, but pied birds appeared both years among the progeny. In this cross the per cent. of dressed

to live weight was 94.24, of drawn to dressed weight was 72.41, and of drawn to live weight was 68.24 per cent.

White China-Brown China Cross, yard 4, in 1897.—In 1896 these two breeds were not crossed, but in 1897 they were mated and placed in yard 4, while the opposite mating was put in yard 16. All the matings in which White Chinas were used, with the exception of yard 13, White China-Embden, in 1896, were almost wholly unproductive of fertile eggs. This was true also of the pure White China mating. The per cents. of goslings to eggs set were greater in 1897 than in 1896, with one exception, the White China-Toulouse mating, from which no fertile eggs were obtained. The White China-Brown China cross gave the fourth poorest result, and only 12.50 per cent. of the eggs set produced goslings. At about 5 weeks old they were smallest of all the goslings raised, averaging 2.21 pounds, and were the only ones which did not average an ounce each in daily growth at that age. At 8 weeks they were still the smallest, and at 10 weeks averaged but 6.35 pounds in weight, when the pure Africans averaged 10.24 pounds. Fattened and sold as green geese they averaged 9.96 pounds alive, and 9.35 pounds dressed. They were classed as "fair." All were of the *Brown China* type and *color*, with the exception that one of the three had a yellow bill, and one a mottled bill, but all had black nails and black claws. Two mature birds averaged 10.19 pounds alive, and 9.84 pounds dressed. The per cent. of dressed to live weight was 96.56, of drawn to dressed weight 78.76, and of drawn to live weight 76.05 per cent.

Brown China-White China Cross, yard 16, 1897.—The per cent. of goslings to eggs set was a little lower than in the preceding case, and second from the lowest, i. e., 10.71 per cent. Only one of the three birds hatched survived to reach the age of 5 weeks, at which time it weighed 2.56 pounds, and next the lowest in weight. At 8 weeks old it weighed 6.13 pounds, and just equaled the average weight of the African-White Chinas, in pen 11. At 10 weeks old it reached 8.13 pounds, or nearly half a pound more than the average of those in yard 11, and 1.78 pounds more than goslings in yard 4.

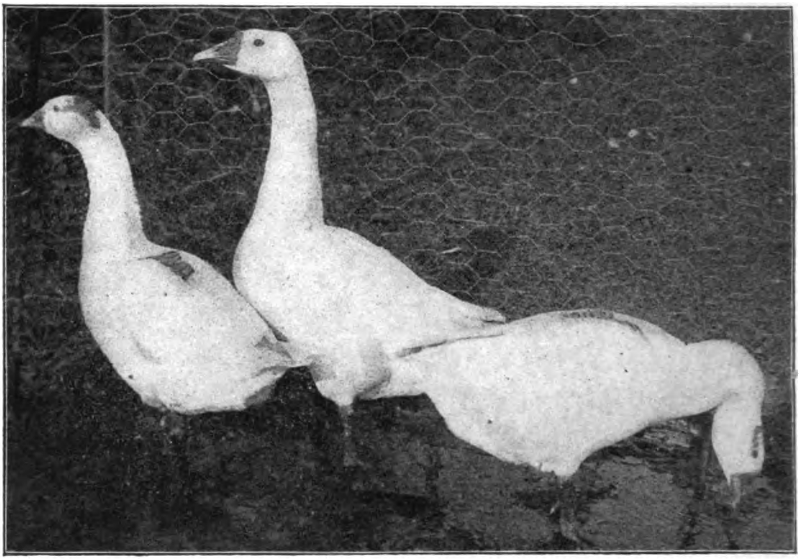

FIG. 34. African-White China Cross Yard 11. 1897.

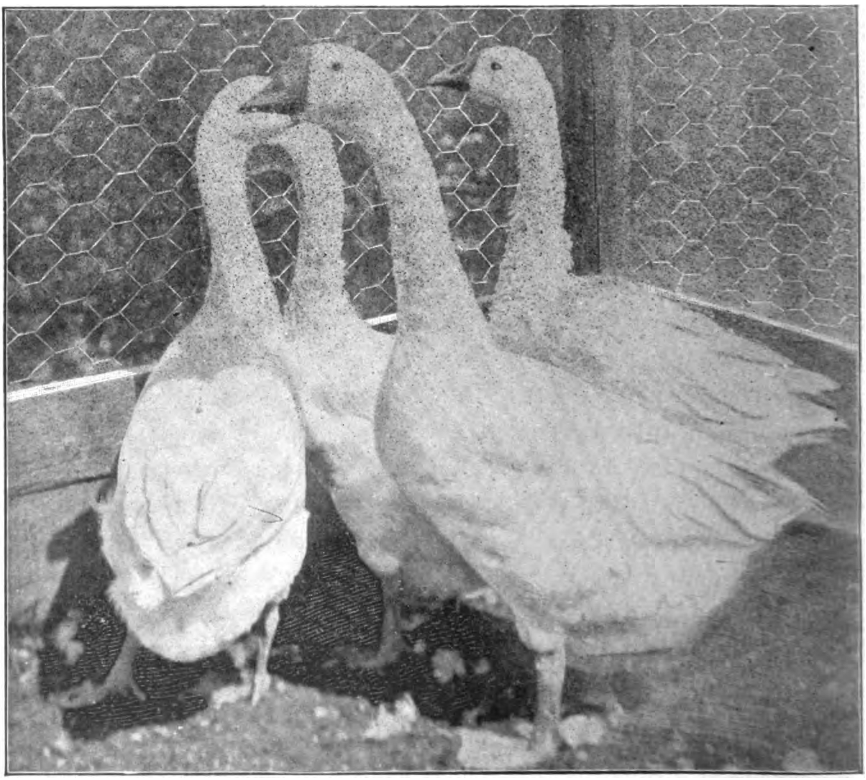

FIG. 35. Yard 22, 1896.

White China $\left\{\begin{matrix}\text{Toulouse}\\ \text{or}\\ \text{Embden.}\end{matrix}\right\}$ Cross.

(Probably White China-Embden Cross.)

Fattened as a green goose it weighed 10.06 pounds, and the dressed weight is recorded as 10.50 pounds: the increase probably due to the taking up of ice water in the process of cooling. This bird was a Brown China in appearance and color, excepting that a little yellow appeared in the bill, giving it a mottled appearance. The fact that no white appeared in either of these crosses would indicate that the Brown China is the stronger type, with great prepotent power.

African-White China Cross, yard 11, in 1897 (Fig. 34).—This mating produced the greatest number of fertile eggs secured from any White China mating in 1897: 43.33 per cent. of the eggs set produced goslings. At about 5 weeks old they equaled in average weight the Brown China-Toulouse cross, in yard 14, weighing 2.86 pounds. At 8 weeks old they weighed 6.13 pounds, and the goslings in yard 14 averaged 6.90 pounds. At 10 weeks old they averaged 7.62 pounds, and goslings in yard 14 were 1.36 pounds heavier. As green geese those in the second hatch averaged 9.35 pounds alive, and 9.14 pounds dressed. These three birds were all dark in color, two resembling Africans and one the Brown China type; all had black bills. They were classed "No. 3" in the market. Those in the third hatch were all white, with light yellow bills and legs, see Fig. 34, and averaged 8.36 pounds alive, and 7.96 pounds dressed. They were classed as "third best birds" in the shipment.

Toulouse-White China Cross, yard 20.—In 1896 only 2.32 per cent. of the eggs set from this mating hatched, and 88.37 per cent. of the eggs were tested out as infertile. In 1897 rather better results were obtained, as 16.12 per cent. of the eggs set hatched goslings. At 10 weeks old the only gosling weighed 8.13 pounds, tieing with the Embden-Brown China cross for the ninth place in average weight. In 1897 this cross at 10 weeks old averaged 9.37 pounds, showing a daily growth of 2.054 ounces. At both the second and third weighings this cross ranked fourth in average weight. One bird was fattened and sent to market as a green goose. It weighed 10.87 pounds alive, and 10.44 pounds dressed.

It was classed as "No. 2." This bird was Toulouse type and color, with, however, a mottled bill having a black nail; and it also had black claws, which are white in both parents. As mature geese, one in 1896 weighed 13 pounds alive, and 11.44 dressed. This bird was white, with yellow bill and legs. Two specimens in 1897 averaged 15.94 pounds alive, and 15.34 pounds dressed. Unfortunately, the description of these two birds was overlooked. One of them weighed alive 19.56 pounds when dressed, November 24th, and has the honor of being the heaviest bird of any breed or cross raised and killed in the two years. A pure bred Embden, dressed at the the same time, weighed almost as much, viz.: 19.44 pounds. The heaviest weight reached by any 1896 gosling was 19.38 pounds, which was the record made by two geese killed February 16, and therefore much older than those killed in 1897. One was an African-Embden cross, and the other a Brown China-Toulouse cross. These four are the only geese killed which have exceeded 19 pounds in weight. The per cent. of shrinkage was as follows: per cent. of dressed to live weight, 96.23; of drawn to dressed weight, 73.33; and of drawn to live weight, 70.57 per cent.

White China-Toulouse Cross, yard 21.—Only 8.82 per cent. of the eggs set produced goslings. At about 10 weeks old they averaged 6.63 pounds each, which was next to Brown China pure, which was lowest of all. As green geese they averaged alive 9.66 pounds, and the recorded dressed weight was 9.65 pounds. One of the two birds was dark like the Toulouse, with a few white feathers, the other dark but had a white breast. The bills were greenish yellow with black nails, and they had white claws. They did not meet with favor in the market, and ranked with the lowest grades sent.

In yard 22, in *1896*, a White China gander was mated with both Embden and Toulouse geese. This yard had a large open pasture in which to roam, provided with water in a small brook. Here, as in other White China crosses, however, there was a large per cent. of infertile eggs. Only 10.41 per cent. of the eggs set were hatched. At about 5 weeks old they ranked fifth in average

weight, and were thrifty. At 10 weeks old they averaged 7.13 pounds, or just half a pound more than the White China-Toulouse cross, in pen 21. As the feathers developed it was quite evident that they were the product of the White China-Embden cross, corresponding closely with the White China-Embden cross from pen 13. At 5 months old they averaged 9.29 pounds, and goslings from pen 13 averaged 10.72 pounds.

Comparative Weights of Pure Bred Geese and Crosses.—In 1896, when about 5 weeks old, Embden goslings ranked third in average weight when all the hatches were considered together. At the weighings at 8 weeks, 10 weeks, and 5 months old, all the pure breeds were exceeded in average weight by four or more crosses, (pages 523–4.) Pure Brown Chinas made the lowest average weight at all four weighings.

In 1897 Pure Toulouse ranked first in average weight at about 5 weeks old, and cross-breds held the next three or more places. At 8 weeks old pure bred Africans held the third place, and cross-breds held the other three of the four greatest average weights. At about 10 weeks old Africans held the first place, having the highest average weight, the daily growth being equal to 2.280 ounces, as against 2.240 ounces per day for the Embden-African cross, which held first place at the same age in 1896. Cross-breds held the next three or more places at 10 weeks old. (See page 575.) No pure White China or Brown China matings were made in 1897, and the lowest average weight recorded at each of the three weighings was for the White China-Brown China cross.

METEOROLOGICAL REPORT.

NATHANIEL HELME.

The work of this department for the past year has been of the usual routine. In the early part of the year the new anemometer, with weekly register, was placed in position on the roof of Davis Hall. There has been no change in the other instruments in use. During the summer weekly reports of the condition of the various crops, and in the winter reports of the depths of snow on the ground, have been sent to the director of the weather service in Boston. Monthly reports of the weather conditions have been published in the Providence Journal and Bulletin, in the Narragansett Times, and, occasionally, in other papers. Daily forecasts of the weather have been published in the Evening Bulletin.

SUMMARY FOR 1897.

Maximum temperature	90°	September 10th.
Minimum temperature	1°	January 20th.
Range for the year	89°	
Highest monthly mean	70.6°	July.
Lowest monthly mean	28.2°	February.
Highest daily mean	76°	September 10th.
Lowest daily mean	6°	January 19th.
Mean temperature of the year	48.3°	

Precipitation.

Total for the year (rain and melted snow)	54.25 inches.	
Largest total for one month	10.25 "	November.
Least total for one month	.89 "	October.

Greatest precipitation in 24 consecutive hours	5.17 inches,		November 2.
Total snowfall for the year	48	"	
Largest total for one month	19½	"	January.
Least total for one month	3	"	March.

Weather.

Number of clear days in the year ...	129
Number of fair days ...	126
Number of cloudy days ...	110
Number of days with precipitation of .01 inch or more ...	128

Prevailing Winds.

N., 1 month; N. E., 1 month; E., 1 month; S. W., 6 months; W., 3 months.

SUMMARY, 1890 TO 1897, INCLUSIVE.

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Maximum temperature	91°	94°	92°	92°	93°	95°	93°	90°
Minimum temperature	3°	5°	—1°	—6°	—9°	—7°	—11°	1°
Mean temperature	48.3°	49.4°	47.8°	46.5°	48.6°	48 2°	47.7°	48.3°
Total precipitation, inches ..	59.25	49.88	42.58	57.83	48.19	49.28	49.87	54.25
Number of clear days	99	116	147	126	110	128	131	129
Number of fair days	143	154	116	130	130	114	112	126
Number of cloudy days	123	95	103	109	125	123	123	110
Number of days with precipitation of .01 inch or more.	120	83	89	131	114	108	109	128

Average mean temperature, 48.1°

Average precipitation, 51.33 inches.

The mean temperature of January was slightly below the average, but was 3° more than that of January, 1896. The precipitation was above the average, and was twice that of January, 1896. The average temperature for eight years was 27.3°, and the average precipitation for nine years was 5.09 inches. The snowfall for the month was 19½ inches.

February temperature was within one tenth of a degree of the average for eight years. The precipitation was about equally divided between rain and snow. There was snow of varying

depth on the ground during the whole of the month. The total precipitation was about one-half the average for nine years.

March temperature was above, and rainfall below, the average. There was but little snow during the month. At the end of the month the frost was out of the ground and some ploughing had been done.

April temperature and rainfall were very near the average for the month. The season was quite well advanced, and much ploughing and sowing were done during the month. There were flurries of snow on the 27th, and freezing weather on the 20th and 21st.

May temperature was about the average, though 2.7° less than the mean for May, 1896. The rainfall was below the average, but was one inch more than the total for May, 1896.

June was much cooler than the average, and the minimum temperature of 38° was the lowest for the month of which we have any record here. Grass grew very rapidly during the month, giving promise of a good crop of hay. The rainfall was above the average.

July temperature was above the average, and the rainfall was nearly twice the average for the month. Much cloudy and wet weater prevailed, and considerable damage was done by the heavy winds and rains to fruit trees and growing crops.

August mean temperature was below, and the rainfall above, the average. Thunder storms were quite frequent, and considerable damage was done by lightning. With one or two exceptions the rainfalls were very heavy and of short duration.

The highest temperature of the year was recorded in September, 90° on the 10th of the month. The rainfall was less than one-fourth of that of September, 1896, and less than one-half of the average for the month for ten years. The first frost which was a killing one, formed on the 28th; ice was also formed on the same date.

October was a month of fine autumn weather. Bright sunny days prevailed during the month, which was the dryest of the year, the rainfall being the least for any month during the year. The temperature was very near to the average, and the rainfall about one-sixth of the average.

November was a month of variable weather, with sudden changes in temperature and frequent storms. The rainfall of the 2d was very heavy, 5.17 inches falling in 24 hours, the heaviest in the same length of time of which we have any record here. The total snowfall was 9 inches, 2 of which fell on the 19th, one on the 20th, and six on the 23d. The mean temperature was slightly below the average.

The temperature of December was about the average for the month, and the precipitation a little more than the average. During the first half of the month there was little or no frost in the ground. The snowfall was one-half of that of November. At the close of December, 1896, there was an average depth of five inches of snow on the ground. At the close of 1897 the ground was entirely bare of snow.

The last frost in the spring formed May 8th, and the first in autumn, September 28th. The first snow fell November 12th, and the last March 14th.

The following tables give the daily features of the weather for each month of the year, and also the highest, lowest, and mean temperature:

WEATHER SUMMARY FOR JANUARY, 1897.

	Temperature.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	35°	16°	25.5°	....	N. E............	Fair.
2	42	28	37	....	S. W............	Cloudy.
3	43	33	38	....	S. W............	Fair.
4	53	33	47	....	S. E............	Cloudy.
5	54	35	41.5	.28	S. W............	Cloudy.
6	35	22	25	1.15	W............	Fair.
7	33	19	24.5	.03	W............	Clear.
8	30	19	22	....	N. E............	Fair.
9	33	14	24	....	Variable........	Clear.
10	42	25	33	....	W............	Fair.
11	33	24	29	....	W............	Fair.
12	23	9	15.5	....	W............	Fair.
13	25	8	16	....	W............	Fair.
14	30	19	24.5	....	N. E............	Cloudy.
15	35	21	28	....	N. E............	Cloudy.
16	40	26	30	....	Variable........	Fair.
17	38	24	35.5	....	S. E............	Cloudy.
18	44	20	30.5	.80	W............	Fair.
19	20	4	6	1.19	W............	Clear.
20	30	1	21	.05	E.	Fair.
21	45	29	39	.14	Variable........	Cloudy.
22	40	30	33	.05	W............	Cloudy.
23	32	20	24	....	W............	Fair.
24	25	14	17	....	W............	Fair.
25	16	2	8.5	....	W............	Clear.
26	29	7	19	....	W............	Clear.
27	28	13	23	....	N. E............	Cloudy.
28	31	17	22.5	1.50	W............	Cloudy.
29	29	17	21	....	W............	Clear.
30	29	9	18	....	W............	Clear.
31	35	12	21	....	Variable........	Clear.
Sum........	1,072	565	800	5.19	....	....
Mean......	34.6	18.2	25.8	....	....	....

Maximum temperature............ 54°.
Minimum temperature............ 1°.

Mean temperature............ 25.8°.
Prevailing wind, west.

WEATHER SUMMARY FOR FEBRUARY, 1897.

	Temperature.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	37°	9°	22°	....	S. W............	Clear.
2	32	17	29	....	N. E............	Cloudy.
3	33	22	25.5	....	N...............	Cloudy.
4	26	16	18	....	N...............	Fair.
5	37	11	24.5	....	Variable.......	Clear.
6	38	24	34	....	E...............	Cloudy.
7	40	35	36	.48	S...............	Fair.
8	41	29	32	.08	S. W............	Fair.
9	39	27	30	....	W...............	Clear.
10	38	22	27.5	....	W...............	Clear.
11	32	15	20.5	....	N...............	Clear.
12	25	14	17	1.00	N. E............	Cloudy.
13	28	9	16	....	W...............	Clear.
14	36	9	27	....	S. W............	Clear.
15	38	23	32	....	Variable.......	Cloudy.
16	37	28	31.5	.23	N. W..........	Fair.
17	40	20	32	....	S. W............	Fair.
18	42	32	35.5	....	W...............	Fair.
19	36	24	27	....	W...............	Clear.
20	36	14	27	....	S. W............	Fair.
21	48	29	38.5	.36	W...............	Cloudy.
22	38	31	35	Trace.	N. E............	Cloudy.
23	42	31	33.5	.55	W...............	Cloudy.
24	35	24	27	.03	W...............	Clear.
25	37	22	31.5	....	S...............	Cloudy.
26	33	21	25	....	Variable........	Clear.
27	23	13	18	....	W...............	Clear.
28	31	9	21	....	W...............	Clear.
Sum........	1,003	580	773.5	2.73	....	....
Mean......	35.8	20.7	27.6	....	....	....

Maximum temperature............ 48°.
Minimum temperature............ 9°.
Mean temperature............ 27.6°.
Prevailing wind, west.

WEATHER SUMMARY FOR MARCH, 1897.

	Temperature.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	33°	5°	24°	.07	Variable.	Fair.
2	49	33	39.5	....	S. W............	Cloudy.
3	45	33	42	.28	S................	Cloudy.
4	43	25	28	....	W...............	Clear.
5	43	20	35.5	.60	E...............	Cloudy.
6	47	30	37	.08	N. W...........	Cloudy.
7	31	18	23.5	....	N. E............	Clear.
8	37	17	30	....	E...............	Fair.
9	43	31	37	.03	S. W............	Cloudy.
10	45	36	39.5	.15	S. W............	Fair.
11	52	28	38.5	....	S. W............	Clear.
12	47	33	41	.18	S. E............	Cloudy.
13	43	25	29	....	W...............	Clear.
14	33	21	28.5	.75	Variable........	Fair.
15	36	24	29	....	W...............	Clear.
16	28	18	20.5	....	W...............	Clear.
17	36	10	25.5	....	W...............	Clear.
18	40	25	34	....	E...............	Cloudy.
19	50	34	40.5	.02	Variable........	Cloudy.
20	39	34	36	.84	N. E............	Cloudy.
21	52	33	41	....	W...............	Fair.
22	53	31	42	.02	S. W............	Cloudy.
23	58	38	43	....	E...............	Fair.
24	41	33	35	.94	Variable........	Fair.
25	43	32	35	....	W...............	Fair.
26	43	27	34	....	W...............	Fair.
27	44	28	34.5	....	W...............	Cloudy.
28	44	28	35	....	N. W...........	Cloudy.
29	53	27	40	....	W...............	Clear.
30	57	29	43	....	N. W.	Clear.
31	53	33	37	....	Variable.	Clear.
Sum.......	1,361	839	1,079	3.96	....	....
Mean......	43.9	27.1	34.8	....	....	....

Maximum temperature............ 58°.
Minimum temperature............. 5°.

Mean temperature............ 34.8°.
Prevailing wind, west.

WEATHER SUMMARY FOR APRIL, 1897.

	TEMPERATURE.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	51°	23°	37°	....	Variable	Clear.
2	64	37	48	....	W..............	Clear.
3	45	29	33	....	N. E............	Clear.
4	49	24	37	....	S. W............	Fair.
5	50	35	46	1.32	S. W............	Cloudy.
6	64	42	49.5	.07	S. W............	Clear.
7	58	38	47	.06	W..............	Fair.
8	53	33	42.5	....	E..............	Cloudy.
9	41	37	38.5	2.63	N. E............	Cloudy.
10	48	35	40	....	N. W............	Cloudy.
11	51	32	39	.21	W..............	Fair.
12	52	31	40.5	....	S. W............	Clear.
13	52	30	45.5	....	S. E............	Fair.
14	59	43	49	.07	S. W............	Cloudy.
15	60	43	46.5	.33	S...............	Cloudy.
16	61	34	45.5	....	W..............	Clear.
17	53	37	46	.08	S. W............	Cloudy.
18	59	33	45	....	W..............	Clear.
19	56	37	43.5	....	S. W............	Clear.
20	40	22	30	....	W..............	Clear.
21	50	23	38	....	S...............	Clear.
22	60	34	46.5	....	S. W............	Clear.
23	62	41	50	....	S. W............	Clear.
24	66	42	51	....	S. W............	Fair.
25	68	44	55	....	S...............	Fair.
26	68	48	52	Trace.	N. W............	Fair.
27	48	34	39	....	N. W............	Cloudy.
28	53	34	40.5	.04	N...............	Fair.
29	65	36	51.5	....	Variable	Fair.
30	71	45	54	....	S. E............	Clear.
Sum........	1,677	1,056	1,326	4.81	....	....
Mean	55.9	35.2	44.2	....	....	....

Maximum temperature............ 71°.
Minimum temperature............. 22°.
Mean temperature............ 44.2°.
Prevailing wind, south west.

WEATHER SUMMARY FOR MAY, 1897.

	Temperature.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	53°	48°	45°	....	E...............	Cloudy.
2	52	42	47	.71	N. E...........	Cloudy.
3	60	44	48	.40	S. E...........	Cloudy.
4	58	43	49	....	S................	Fair.
5	68	39	53	....	N. E...........	Fair.
6	66	46	53.5	....	N. E...........	Clear.
7	58	40	47	....	S................	Cloudy.
8	59	36	46	....	N. W...........	Clear.
9	69	40	55.5	....	W...............	Fair.
10	78	52	63	.08	S. W...........	Fair.
11	69	50	56.5	....	S. W...........	Clear.
12	58	48	54.5	.12	S. W...........	Cloudy.
13	62	53	56.5	.49	S................	Cloudy.
14	60	50	53	.31	E...............	Cloudy.
15	72	50	56	....	S. W...........	Cloudy.
16	56	48	50	.15	N. E...........	Cloudy.
17	67	48	54.5	....	N. E...........	Cloudy.
18	74	48	61	....	S. W...........	Clear.
19	69	46	53.5	....	S. W...........	Clear.
20	66	48	57	....	S. W...........	Clear.
21	69	52	58	.12	S. W...........	Fair.
22	68	45	54	....	N...............	Clear.
23	65	43	57	....	Variable........	Clear.
24	63	52	57.5	.05	S................	Cloudy.
25	67	58	57	.53	S. W...........	Fair.
26	68	43	54.5	....	N. W...........	Fair.
27	61	47	50.5	....	N. W...........	Cloudy.
28	73	46	57.5	....	S. W...........	Fair.
29	73	51	59.5	....	S. W...........	Clear.
30	72	44	60	....	S. W...........	Fair.
31	64	54	60	.99	S. W...........	Cloudy.
Sum........	2,017	1,439	1,685	3.95	....	....
Mean......	65.1	46.4	54.4	....	....	....

Maximum temperature............ 78°. Mean temperature............ 54.4°.
Minimum temperature............ 36°. Prevailing wind, south west.

WEATHER SUMMARY FOR JUNE, 1897.

	TEMPERATURE.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	61°	44°	51°	.05	W..............	Clear.
2	69	38	55	....	W..............	Clear.
3	68	49	59	....	S. W...........	Fair.
4	80	58	65.5	....	S. W...........	Fair.
5	67	55	58	.18	N. E...........	Cloudy.
6	60	51	53	....	N. E...........	Cloudy.
7	59	49	52.5	....	N. E...........	Cloudy.
8	60	48	53	.04	N. E...........	Cloudy.
9	56	50	54.5	2.62	N. E...........	Cloudy.
10	62	51	54	....	N. W...........	Cloudy.
11	75	47	61.5	.02	W..............	Clear.
12	75	56	68	.20	S. W...........	Fair.
13	77	52	60.5	.44	Variable........	Fair.
14	67	50	54	.07	Variable.......	Cloudy.
15	78	52	63	....	S. W...........	Clear.
16	77	51	64	....	W..............	Clear.
17	74	51	63	....	N. E...........	Cloudy.
18	78	56	64	....	S. W...........	Clear.
19	79	52	65	....	Variable.......	Clear.
20	70	58	61	.21	W..............	Cloudy.
21	68	45	57	....	W..............	Clear.
22	78	44	60	....	S. W...........	Clear.
23	75	52	64	....	S. W...........	Clear.
24	79	58	68	....	S. W...........	Fair.
25	81	62	70	....	S. W...........	Fair.
26	78	55	62.5	....	W..............	Clear.
27	70	44	59	....	W..............	Clear.
28	79	46	66	....	Variable.......	Fair.
29	81	55	69	....	Variable.......	Cloudy.
30	83	60	69	.65	N. W...........	Fair.
Sum........	2,150	1,539	1,819	4.48	....	....
Mean......	72	51.3	60.6	....	....	....

Maximum temperature............ 83°.
Minimum temperature............ 38°.
Mean temperature............ 60.6°.
Prevailing wind, south west.

WEATHER SUMMARY FOR JULY, 1897.

	Temperature.			Precipitation.	Prevailing Wind.	
	Max.	Min.	Mean.			
1	82°	54°	68°	....	Variable	Clear.
2	75	58	66.5	.61	S. W............	Cloudy.
3	76	60	68	....	S................	Fair.
4	77	59	68	....	S................	Fair.
5	85	65	75	....	W...............	Fair.
6	82	62	72	....	S................	Cloudy.
7	82	65	73.5	....	S...............	Fair.
8	83	64	73.5	....	S. W............	Fair.
9	86	66	76	....	Variable	Clear.
10	87	64	75.5	....	Variable	Clear.
11	82	60	71	.05	Variable	Fair.
12	81	69	75	.06	Variable	Cloudy.
13	79	67	73	.29	S. E............	Cloudy.
14	77	65	71	.62	S. W............	Cloudy.
15	82	59	70.5	....	S. W............	Clear.
16	84	60	72	....	S. E............	Clear.
17	84	62	73	....	S. E............	Fair.
18	81	65	73	....	W...............	Cloudy.
19	76	62	69	.75	S. E............	Cloudy.
20	81	66	73.5	.02	S................	Fair.
21	78	66	72	.32	Variable	Cloudy.
22	74	67	70.5	1.10	S. W............	Cloudy.
23	81	65	73	.07	S. W............	Cloudy.
24	80	63	71.5	.19	W...............	Fair.
25	80	61	70.5	.04	Variable	Fair.
26	70	57	63.5	....	N. E............	Cloudy.
27	70	55	62.5	....	N. E............	Cloudy.
28	70	56	63	....	N. E............	Cloudy.
29	75	57	66	2.20	Variable	Cloudy.
30	78	57	67.5	.01	W...............	Clear.
31	83	60	71.5	.02	S. W............	Fair.
Sum........	2,461	1,916	2,188.5	6.35	....	....
Mean......	79.4	61.8	70.6	....	....	....

Maximum temperature............ 87°.
Minimum temperature............ 54°.
Mean temperature............ 70.6°.
Prevailing wind, south west.

WEATHER SUMMARY FOR AUGUST, 1897.

	Temperature.			Precipitation.	Prevailing Wind.	
	Max.	Min.	Mean.			
1	78°	58°	68°	....	W...............	Clear.
2	78	58	68	.05	S. W............	Fair.
3	80	59	60.5	....	S. W............	Fair.
4	82	64	73	....	S. W....	Cloudy.
5	71	55	63	.65	N. E............	Fair.
6	80	57	68.5	....	Variable	Clear.
7	80	59	69.5	....	Variable	Clear.
8	80	57	68.5	....	S. W............	Fair.
9	80	57	68.5	....	S. W............	Fair.
10	76	59	67.5	....	S. W............	Fair.
11	75	62	68.5	.23	E...............	Fair.
12	79	57	68	.02	W...............	Clear.
13	76	54	65	....	W...............	Clear.
14	83	58	70.5	....	S. W............	Fair.
15	82	66	74	.09	S. W............	Cloudy.
16	76	64	70	.90	S. W............	Cloudy.
17	76	57	66.5	....	W...............	Clear.
18	78	52	65	.78	S. E............	Fair.
19	76	59	67.5	....	S. W............	Cloudy.
20	76	57	66.5	....	W...............	Fair.
21	75	48	61.5	....	S. W............	Clear.
22	75	60	67.5	.56	S...............	Cloudy.
23	65	59	62	....	N. E............	Cloudy.
24	70	55	62.5	1.08	N.	Cloudy.
25	73	48	60.5	....	S...............	Fair.
26	78	59	68.5	....	W...............	Clear.
27	77	52	64.5	....	Variable	Clear.
28	79	63	71	....	S. W............	Fair.
29	78	57	67.5	....	N.	Clear.
30	81	58	69.5	....	S. W............	Fair.
31	77	56	66.5	....	W...............	Fair.
Sum........	2,390	1,780	2,085	4.31	....	....
Mean	77.1	57.4	67.3	....	....	....

Maximum temperature............ 83°.
Minimum temperature............. 48°.

Mean temperature............ 67.3°.
Prevailing wind, south west.

WEATHER SUMMARY FOR SEPTEMBER, 1897.

	Temperature.			Precipitation.	Prevailing Wind.	
	Max.	Min.	Mean.			
1	79°	52°	65°	....	S. W............	Clear.
2	65	57	60	.64	Variable	Fair.
3	68	51	56	....	N. E............	Clear.
4	70	46	58	....	Variable	Clear.
5	78	51	64.5	....	N. W	Clear.
6	87	56	74	....	W...............	Clear.
7	73	57	62	....	N. E............	Fair.
8	73	57	64.5	....	S. W............	Cloudy.
9	87	62	72	....	W...............	Fair.
10	90	64	76	....	W...............	Clear.
11	89	61	70.5	....	W...............	Fair.
12	68	48	56	....	N. E.....	Clear.
13	72	52	67	.06	S. W............	Cloudy.
14	72	52	58	....	N. W	Clear.
15	71	48	57	....	N. W	Clear.
16	77	48	64	.07	S. W............	Fair.
17	75	56	62	.03	N...............	Fair.
18	65	52	51	....	N. W	Clear.
19	70	45	59.5	....	S................	Clear.
20	69	52	57	....	N. E............	Cloudy.
21	62	42	49	....	W...............	Clear.
22	60	40	51	....	N. E............	Cloudy.
23	61	49	55	.25	N. E............	Cloudy.
24	68	50	56	.37	S. E............	Fair.
25	76	49	59	....	W...............	Clear.
26	75	50	60	.34	S. W............	Cloudy.
27	61	42	48	....	N. W	Clear.
28	61	32	45.5	....	W...............	Clear.
29	70	35	54	....	Variable	Clear.
30	73	45	59	....	S. W............	Clear.
Sum........	2,165	1,491	1,790.5	1.76	....	....
Mean......	72.2	49.7	59.7	....	....	....

Maximum temperature............ 90°.
Minimum temperature............. 32°.
Mean temperature....... .... 59.7°.
Prevailing wind, west.

WEATHER SUMMARY FOR OCTOBER, 1897.

	TEMPERATURE.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	83°	52°	67.5°	....	Variable........	Clear.
2	61	42	51.5	....	N. E............	Clear.
3	61	36	48.5	....	N. E............	Clear.
4	68	38	35	....	Variable........	Clear.
5	60	40	54.5	....	S. W............	Clear.
6	68	45	56.5	....	S. W............	Clear.
7	66	47	56.5	....	Variable........	Cloudy.
8	62	41	51.5	....	S. W............	Clear.
9	67	41	54	....	S. W............	Clear.
10	55	32	43.5	....	E................	Clear.
11	65	38	51.5	....	S. E............	Cloudy.
12	70	60	65	.30	S................	Cloudy.
13	71	51	61	....	W...............	Clear.
14	64	42	53	....	Variable........	Clear.
15	75	49	62	....	S. W............	Clear.
16	83	57	70	....	S. W............	Fair.
17	67	37	52	....	N. W............	Clear.
18	58	31	44.5	....	S. W............	Clear.
19	64	37	50.5	....	S. W............	Clear.
20	61	42	51.5	....	N. E............	Cloudy.
21	52	42	47	.19	N. E............	Cloudy.
22	55	37	46	....	N. E............	Fair.
23	56	34	45	....	N. E............	Clear.
24	50	35	42.5	.30	N. E............	Cloudy.
25	58	45	51.5	....	N. E............	Cloudy.
26	62	43	52.5	....	N. E............	Clear.
27	63	38	50.5	....	N. E............	Fair.
28	62	45	53.5	.08	E................	Cloudy.
29	56	38	47	.02	N. W............	Fair.
30	48	28	38	....	W...............	Clear.
31	53	28	40.5	....	S. W............	Clear.
Sum........	1,958	1,271	1,612	.89	....	....
Mean......	63	41	52	....	....	....

Maximum temperature............ 83°.
Minimum temperature............ 28°.

Mean temperature............ 52°.
Prevailing wind, north east.

WEATHER SUMMARY FOR NOVEMBER, 1897.

	Temperature.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	57°	41°	49°	.48	S. E.	Cloudy.
2	63	48	55.5	5.17	N. E	Cloudy.
3	60	41	50.5	.15	W.	Fair.
4	59	34	46.5	....	W.	Clear.
5	60	38	49	....	S. E.	Fair.
6	68	43	55.5	....	S. W	Cloudy.
7	50	38	44	....	W.	Cloudy.
8	50	30	40	.06	S. W	Cloudy.
9	58	41	49.5	.79	Variable	Fair.
10	49	33	41	....	W.	Clear.
11	50	28	39	.18	Variable	Cloudy.
12	47	32	39.5	.95	W.	Fair.
13	45	33	39	....	W.	Clear.
14	42	29	35.5	....	W	Clear.
15	51	28	39.5	.04	S. E.	Cloudy.
16	61	49	55	....	S. W.	Fair.
17	56	30	43	.23	N. W.	Fair.
18	38	21	29.5	....	W.	Clear.
19	30	23	26.5	.20	N. E	Cloudy.
20	40	24	32	.11	N. E.	Cloudy.
21	58	40	49	....	S. W	Fair.
22	47	32	39.5	....	N.	Cloudy.
23	32	18	25	.50	N.	Fair.
24	30	5	17.5	....	W.	Clear.
25	45	28	36.5	....	S. W	Cloudy.
26	60	45	52.5	.15	S. W	Cloudy.
27	57	28	42.5	1.07	W.	Fair.
28	35	18	26.5	....	N. E.	Clear.
29	45	28	36.5	.22	Variable	Cloudy.
30	40	22	31	....	N. W.	Clear.
Sum	1,483	948	1,215.5	10.25	....	....
Mean	49.4	31.6	40.5	....	....	....

Maximum temperature............ 68°.
Minimum temperature............ 5°.
Mean temperature............ 40.5°.
Prevailing wind, west.

WEATHER SUMMARY FOR DECEMBER, 1897.

	Temperature.			Precipitation.	Prevailing wind.	
	Max.	Min.	Mean.			
1	40°	19°	29.5°	Trace.	Variable........	Cloudy.
2	40	25	32.5	....	W...............	Fair.
3	28	23	25.5	.23	N. E............	Cloudy.
4	42	25	33.5	.09	N. E............	Cloudy.
5	53	32	42.5	.48	W...............	Fair.
6	38	27	32.5	....	N. E............	Fair.
7	30	27	31.5	.63	N. E............	Cloudy.
8	40	28	34	....	W...............	Cloudy.
9	55	28	41.5	.03	Variable........	Cloudy.
10	53	38	45.5	.03	S. W............	Fair.
11	56	44	50	....	S. W............	Cloudy.
12	54	38	46	.54	N. E............	Cloudy.
13	42	29	35.5	....	N. E............	Fair.
14	49	36	42.5	1.69	N. E............	Cloudy.
15	55	41	48	1.29	Variable........	Cloudy.
16	45	39	42	....	S. W............	Fair.
17	48	33	40.5	.02	S. W............	Fair.
18	43	24	33.5	....	W...............	Clear.
19	25	14	19.5	....	W...............	Clear.
20	26	10	18	.05	Variable.......	Cloudy.
21	39	24	31.5	.39	N. W............	Fair.
22	30	21	25.5	.05	W...............	Cloudy.
23	30	20	25	....	W...............	Cloudy.
24	20	9	14.5	....	W...............	Clear.
25	28	8	18	....	W...............	Clear.
26	32	26	29	.37	N. E............	Cloudy.
27	33	20	26.5	....	Variable........	Fair.
28	25	12	18.5	....	W...............	Clear.
29	30	8	19	.15	W...............	Fair.
30	45	30	37.5	....	W...............	Cloudy.
31	40	30	35	.21	E...............	Cloudy.
Sum........	1,220	788	1,004	6.25	....	....
Mean......	39.3	25.4	32.4	....	....	....

Maximum temperature............ 56°.
Minimum temperature............ 8°.
Mean temperature............ 32.4°
Prevailing wind, west.

DONATIONS.

BOOKS.—1897.

Tenth Biennial Report of the State Board of Agriculture of Kansas, Vol. 15, F. D. Coburn, Secretary.

Report of the Commissioner of Education, 1894-95, Vol. I, II, Wm. T. Harris, Commissioner.

Thirty-eighth Annual Report of the Horticultural Society of Missouri, 1895, L. A. Goodman, Secretary.

City of St. Joseph, Mo., Municipal Reports, etc., 1895-96.

Report of the Superintendent of Public Instruction, State of Wyoming, 1895-96, Estelle Reel, Superintendent.

Bulletins of the New York Botanical Garden, N. L. Britton, Secretary.

The American Fruit Culturist, by Thomas, Wm. Wood & Co.

Maine School Report, W. W. Stetson, State Superintendent.

Report of Railroad Commissioner, Rhode Island, 1896, E. L. Freeman.

Report of the Commissioner of Agriculture, for 1895, State of New York, C. A. Wieting, Commissioner.

Report on Field Experiments for the year 1895, Prof. Thomas Winter, North Wales.

The Nasal Organs of Pipa Americana, by Irving Reed Bancroft.

On a New Genus and Two New Species of Macrurous Crustacea, by J. S. Kingsley.

Annual, No. 9, (1896) Minnesota Farmers' Institute, O. C. Gregg, Superintendent.

Report of the State Board of Agriculture of Virginia, 1896, Thomas Whitehead, Commissioner.

Forty-fourth Annual Report of the Massachusetts State Board of Agriculture, Wm. R. Sessions, Secretary.

Report of the Rothamsted Field Experiments, Sirs John Bennet Lawes, and J. Henry Gilbert.

The Fertility of the Land, The Macmillan Company.

Ninth Report of the Commissioner of Industrial Statistics of Rhode Island, Henry E. Tiepke, Commissioner.

Minnesota Botanical Studies, 2 vols., Geological and Natural History Survey of Minnesota.

List of Seeds Available for Exchange, 1897, Botanic Gardens, Sydney, New South Wales.

American Grasses, F. Lamson Scribner.

Forty-fifth Annual Report, Boston Public Library, 1896-97.

Rhode Island School Reports, 1896, T. B. Stockwell, Commissioner.

Proceedings of the New York Farmers, 1896-97, Thomas Sturgis, Secretary.

Annual Report of the Operations of the United States Life Saving Service, 1896, H. M. Knowles.

Transactions of the Massachusetts Horticultural Society, Part III, 1895, Part II, 1896, Robert Manning, Secretary.

Ninth Report of the State Board of Health of the State of Maine, 1894-95, A. G. Young, Secretary.

Fifth Biennial Report of the State Board of Horticulture of the State of California, 1895-96, B. M. Lelong, Secretary.

Annual Report of California State Board of Trade for 1896, Gen. N. P. Chipman.

California, the Land of Promise, California State Board of Trade.

Proceedings of the American Philosophical Society, December.

Letters on the Diseases of Plants, N. A. Cobb, New South Wales.

Eighth Report, Missouri Botanical Garden, 1897, Wm. Trelease, Director.

The Common Crow, by N. A. Cobb, Department of Agriculture, Sydney, New South Wales.

Report of the Commissioner of Education, 1895-96, Vols. I and II, Dr. Wm. T. Harris, Commissioner.

Annual Report of the Department for the Insane of the Pennsylvania Hospital, Dr. E. E. Josselyn.

Twelfth Annual Report of the State Board of Agriculture of Rhode Island, George A. Stockwell, Secretary.

Fourth Annual Report on Births, Marriages, Divorces, and Deaths in the State of Maine, 1895, A. G. Young, Registrar.

Sixty-second Annual Report of the Board of Directors of the Providence Athenæum, P. S. Jastram, Secretary.

Report of the Pennsylvania Department of Agriculture, 1896, John Hamilton.

Manual of Free High Schools in Wisconsin, J. Q. Emery, State Superintendent.

SEEDS.

Seeds, Wm. Atlee Burpee & Co.

Seeds, W. O. Arnold.

Seeds, Eastman Seed Co.

Lettuce seed, Peter Henderson & Co.

Eighteen pkgs. vegetable seed; 14, flower seed, W. Atlee Burpee & Co.

Several pkgs. lettuce, radish, and cucumber seeds, Jas. J. H. Gregory & Son.

Four pkgs. grass seed, A. F. & F. Bray.

Fifteen pkgs. seed, W. E. Barrett & Co.

Six pkgs. seed, Halliday Bros.

Four pkgs. seed, C. W. Willard.

Lettuce seed, Toogood & Sons, England.

Vetch, oat, grass, buckwheat, clover, and corn seeds, U. S. Department of Agriculture.

Beet seed, Leber & Meyer.

Rye seed, Jos. Breck & Sons.

Rye seed, Plant Seed Co.

Sugar beet seed, Wohanka Co.

MISCELLANEOUS.

One case Rose Leaf Extract of Tobacco (1-5 gal. can), Louisville Spirit Cured Tobacco Co.

Twenty-six lantern slides, German Kali Works.

One bottle of Ceres Powder, C. M. Köedt.

Sample of material used for the destruction of canker worms on trees, Fairmount Tree Protector Co.

Wheelbarrow Brush Sprayer, Melville Bull.

Utility Pump, Cary Novelty Co.

EXCHANGES.

Agricultural Epitomist, Indianapolis, Ind.
Agricultural Student, Columbus, Ohio.
American Agriculturist, New York, N. Y.
American Cider and Vinegar Maker, New York. N. Y.
American Cultivator, Boston, Mass.
American Horse Breeder, Boston and New York.
American Poultry Journal, Chicago, Ill.
California Cultivator and Poultry Keeper, Los Angeles, Cal.
Connecticut Farmer, Hartford, Conn.
Cotton Planters' Journal, Memphis, Tenn.
Elgin Dairy Report, Elgin, Ill.
Farmers' Magazine, Springfield, Ill.
Farmers' Voice, Chicago, Ill.
Farm, Field and Fireside, Chicago, Ill.
Fancier, Graham, N. C.
Fancy Fowls, Hopkinsville, Kentucky.
Farming World, Clinton, Iowa.
Farm News, Springfield Ohio.
Farm Poultry, Boston, Mass.
Feathered World, London, England.
Gentleman Farm Magazine, Chicago, Ill.
Green's Fruit Grower, Rochester, N. Y.
Hoard's Dairyman, Fort Atkinson, Wis.
Holstein Register, Brattleboro, Vt.
Homestead, Des Moines, Iowa.
Louisiana Planter, New Orleans, La.
Loft, Burrow and Aviary, Worcester, Mass.

Market Basket, Philadelphia, Pa.
Market Garden, Minneapolis, Minn.
Massachusetts Ploughman, Boston, Mass.
Mirror and Farmer, Manchester, N. H.
Montana Fruit Grower, Missoula, Mont.
National Stockman and Farmer, Pittsburgh, Pa.
Nebraska Farmer, Omaha, Neb.
New England Fancier, Yarmouthport, Mass.
New England Farmer, Boston, Mass.
New England Florist, Boston, Mass.
New England Homestead, Springfield, Mass.
Ohio Farmer, Cleveland, Ohio.
Pigeon Keepers' Guide, Medford, Mass.
Poultry Herald, St. Paul, Minn.
Poultry Keeper, Parkesburg, Pa.
Poultry Monthly, Albany, N. Y.
Practical Dairyman, Chatham, N. Y.
Practical Farmer, Philadelphia, Pa.
Reliable Poultry Journal, Quincy, Ill.
Ruralist, East New Market, Md.
Rural New Yorker, New York, N. Y.
Southern Fancier, Atlanta, Ga.
Southern Farm Magazine, Baltimore, Md.
Southern Letter, Tuskegee, Ala.
Southern Planter, Richmond, Va.
Southwestern Farmer and American Horticulturist, Wichita, Kansas.
Stock Keeper, Boston, Mass.
Sugar Beet, Philadelphia, Pa.
Vermont Farmers' Advocate, Burlington, Vt.
Wallace's Farmer, Des Moines, Iowa.
Western Fruit Grower, St. Joseph, Mo.
West Virginia Farm Review, Charlestown, W. Va.
Wool Record, New York, N. Y.

LIST OF STATION PUBLICATIONS FROM DATE OF ORGANIZATION TO 1898.

Year.	Number.		Title.	Pages.
*1888.	First Annual Report.		Report of Board of Managers	27
*1889.	Bull.	1.	Organization of Experiment Station	13
* "	"	2.	The Farm, Historical, Physical and Geological Description	16
* "	"	3.	Stock Feeding	40
* "	"	4.	Bee Keeping. Establishment of the Apiary	32
* "	"	5.	Potatoes. Meteorological Summary	10
"	Second Annual Report.		Report of the Director. Reprints of Bulletins 1 to 4, inclusive, and brief reports of the heads of Divisions	124
*1890.	Bull.	6.	Milk Fever, or Parturient Apoplexy in Cows	24
* "	"	7.	Catalogue of Fruits. Meteorological Summary. Report of the Apiarist	40
* "	"	8.	Soils and Fertilizers	34
* "	"	9.	Experiments in Apiculture	24
* "	Third Annual Report.		Report of Director. Crops and Field Experiments. Co-operative Field Experiments with Fertilizers on Indian Corn. Experiments with Potatoes (varieties). Experiments with Bordeaux Mixture as a Preventive of the Potato Blight. Trials of Varieties of Fruits and Vegetables. Reports of Divisions	196
*1891.	Bull.	10.	Mixed Foods in Cases of Faulty Appetite in Horses and Neat Stock: Including Notice of Patented and Proprietary Foods. Sore Shoulders in Horses	8
* "	"	11.	The State Fertilizer Law as it is and as it might be. Commercial Valuations of Fertilizer Stock. Analyses of Commercial Fertilizers, State Inspection, 1891. Analyses of Miscellaneous Materials. Meteorological Summary	20
* "	"	12.	Further Analyses of Commercial Fertilizers Collected under the State Inspection, 1891, with Comments	12

* Out of print.

Year.	Number.	Title.	Pages.
*1891.	Bull. 13.	Concluded list of Fertilizer Analyses, State Inspection, 1891. Analyses of Miscellaneous Materials	18
* "	" 14.	Notes on the Potato Scab and Bordeaux Mixture as a Preventive of Potato Scab and of Potato Blight. Notes on Transplanting Onions...	18
*1892.	Fourth Annual Report.	Report of Director. Field and Plot Experiments. Co-operative Field Experiments with Fertilizers on Indian Corn. Brief Reports of Divisions......................	118
* "	Bull. 15.	Treatment of Loose Smut of Oats. Fungicides and Insecticides. Black Rot of the Grape, and Apple Scab, Codling Moth, Cankerworm and Plum Curculio.......	25
"	" 16.	The New Fertilizer Law for Rhode Island. Selling Price of Fertilizer Stock. Analyses of Commercial Fertilizers, State Inspection, 1892. Miscellaneous Ayalyses..	16
"	" 17.	Analyses of Commercial Fertilizers, State Inspection, 1892..	8
"	" 18.	Analyses of Commercial Fertilizers, State Inspection, 1892. A Word of Caution in the Purchase of Wood Ashes	8
"	" 19.	Concluded List of Fertilizer Analyses, with Summaries and Comments.....	12
*1892	" 20.	The Production of Capons. Experiments in Caponizing. Prices of Capons, Broilers, Roasters and Fowls in Boston and New York Markets. When to Make Capons, the Time to Sell, and How to Prepare for Market. Caponizing Tools, and How to Perform the Operation	42
* "	Fifth Annual Report.	Report of Director. Winter and Spring Application of Ashes to Newly Seeded Meadow. Shrinkage in Curing Field Corn. Tests of Varieties of Oats. Jansen Hot Water Treatment for Prevention of Smut of Oats. Fertilizer Experiments with Oats. Trials of Different Forms of Phosphates. Trials of Muskmelons. Leguminous Crops. Co-operative Field Experiments on Indian Corn. Potato Scab. Trial of Lawn Grasses. Remedies for the Rose-Bug. Cross-breeding of Poultry. Reports of Divisions	140

* Out of print.

Year.	Number.	Title.	Pages.
1893.	Bull. 21.	Sea-Weeds. Agricultural Value and Chemical Composition	40
"	" 22.	Strawberries. Cultivation and Varieties.	22
"	" 23.	Fertilizers. Commercial and Miscellaneous.	18
"	" 24.	Fertilizers. Analyses of Commercial	8
* "	" 25.	Turkeys. Experiments with; Management of, by Successful Producers; Wild Turkey Crosses, Their Desirability, and Where They may be Obtained	42
"	" 26.	Fertilizers. Oats. Potato Scab	32
"	Sixth Annual Report.	Report of Director. Rotation of crops. Co-operative Field Experiments. On the Occasional Ill Effect of Sulfate of Ammonia as a Manure, and the Use of Air-slacked Lime in Overcoming the Same. On the Effect of Air-slacked Lime Used in Connection with Certain Forms of Organic Nitrogen. Applying Liquid Manure with Hydrant Water. New Varieties of Strawberries. Seed Examination. Experiments with Turkeys. Diseases of Turkeys. Reports of Divisions	165
1894.	Bull. 27.	Leaf Blight of the Pear. Raspberries; Distribution of Plants	12
"	" 28.	Rhode Island Soils. Fertilizers	32
"	" 29.	Fertilizers. Commercial and Special Formula	16
"	" 30.	Fertilizers. Potato Scab	30
" Leaflets.	Circular Bull. 1.	Plan of Soil Test. Co-operative Test of Varieties of Vegetable and Field Seeds.	
	" 2.	Request for Information Regarding "Black Head" of Turkeys.	
	" 3.	List of Experiments in Progress.	
1894.	Seventh Annual Report.	Report of Director. Field Experiments. Soil Test with Fertilizers and Plants. Growth of Various Plants upon an Upland Acid Soil Before and After Liming. On the Substitution of Soda for, and Its Value in Connection with, Potash. On the Fungous Parasites of the Apple and Pear. Infectious Disease of Turkeys. Reports of Divisions.	135
1895.	Bull. 31.	Some Special Orchard Treatment of the Apple, Pear and Quince	18

* Out of print.

Year.	Number.	Title.	Pages.
1895.	Bull. 82.	Analyses of Commercial Fertilizers.	12
"	" 83.	Fertilizers. Potatoes. Potato Scab	52
"	" 84.	Analyses of Fertilizers. Home-Mixed Fertilizers	48
"	" 85.	Garden Seeds	40
"	Eighth Annual Report.	Report of Director. Relative Growth of Common Sorrel and Clover upon an Upland Acid Soil Before and After Liming. Soil Tests with Plants and Fertilizers. On the growth of Various Plants upon an Upland Acid Soil Before and After Liming. On the Substitution of Soda for, and its Value in Connection with, Potash. The Recognition of the Acidity of Upland Soils and Its Bearing upon Agricultural Practice. Ammonium Thiocyanate as an Impurity in Ammonium Sulfate. Heating Greenhouses; trials of different kinds of piping. Experiments with Indian Corn. Forage Plants. Leguminous Plants Grown without Nitrogen and with Different Quantities. Three Seasons' Experiments Cross Breeding of Geese. Reports of Divisions	202
1896.	Bull. 36.	Potato Culture. Hastening Maturity	28
"	" 37.	Apple Culture	18
"	" 38.	The Bordeaux Mixture	12
"	" 39.	Analyses of Commercial Fertilizers	10
"	" 40.	Fertilizers. Potato Scab	28
"	" 41.	Spinach	36
"	" 42.	Fertilizers	20
"	Ninth Annual Report.	Report of Treasurer. Report of Director. Oysters in Point Judith Pond. Report of Horticultural Division. Test of Garden Seeds. The Fairy Ring Disease of Carnations. The Carnation Rust. Report of Chemical Division. On the Substitution of Soda for, and Its Value in Connection with, Potash. Further Observations upon the Growth of Various Plants upon an Acid Upland Soil, Limed and Unlimed. Continued Observations for the Purpose of Determining in How Far the Results Secured in a Soil Test, with a Given Plant, are Applicable to Others. Further Observations upon the Growth of Barley upon an Acid Upland Soil, Limed and Unlimed. (*Con. p. 644.*)	

BULLETINS

AND

ANNUAL REPORT

OF THE

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION,

FOR THE

YEAR 1897.

PROVIDENCE:
E. L. FREEMAN & SONS, STATE PRINTERS.
1898.

INDEX

OF THE

BULLETINS AND ANNUAL REPORT

OF THE

Rhode Island Agricultural Experiment Station,

FOR THE YEAR 1897.

PAGE.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

PAGE.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45: for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

Note.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

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NOTE.—For pp. 1-14 see Bul. 43; for pp. 15-64 see Bul. 44; for pp. 65-82 see Bul. 45; for pp. 83-110 see Bul. 46.

NOTE.—For pp. 1–14 see Bul. 43; for pp. 15–64 see Bul. 44; for pp. 65–82 see Bul. 45; for pp. 83–110 see Bul. 46.

State of Rhode Island and Providence Plantations.

ELEVENTH ANNUAL REPORT

OF THE

RHODE ISLAND

AGRICULTURAL EXPERIMENT STATION,

1898.

PART II.

OF THE

ELEVENTH ANNUAL REPORT

OF THE

CORPORATION, BOARD OF MANAGERS,

OF THE

Rhode Island College of Agriculture and Mechanic Arts,

MADE TO THE

GENERAL ASSEMBLY AT ITS JANUARY SESSION, 1899.

[PART I. OF THIS REPORT — COLLEGE CATALOGUE — IS PRINTED UNDER SEPARATE COVER.]

PROVIDENCE, R. I.
E. L. FREEMAN & SONS, PRINTERS TO THE STATE.
1899.

BOARD OF MANAGERS

OF THE

RHODE ISLAND

COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

EXPERIMENT STATION STAFF.

JOHN H. WASHBURN, Ph.D.,	President of the College.
A. A. BRIGHAM, Ph.D.,	Director and Agriculturist.*
FRED W. CARD, M.S.,	Horticulturist.†
H. J. WHEELER, Ph.D.,	Chemist.
GEORGE W. FIELD, Ph.D.,	Biologist.
J. A. TILLINGHAST,	Assistant, Field Experiments.
BURT L. HARTWELL, B.S.,	Assistant Chemist.
G. E. ADAMS, B.S.,	Photographer, Assistant Horticulturist.
JOHN BARLOW, B.S.,	Assistant Biologist.‡
M. H. ARNOLD,	Poultryman.
NATH'L HELME,	Meteorologist.
BERTHA E. BENTLEY,	Stenographer.

*Elected February 4, 1898.

† Commencing September 1st, 1898.

‡ September to December.

The publications of the Station will be mailed free "to such individuals actually engaged in farming as may request the same." The Station desires the co-operation of the farmers of the State in the work of investigation, and any facts of especial interest concerning animal or vegetable growth or disease are solicited. Visitors are always welcome. Railroad station, telegraph, express and post-office—Kingston, Rhode Island.

LETTER OF TRANSMITTAL.

To His Excellency Elisha Dyer, Governor, and the Honorable the General Assembly of the State of Rhode Island, at its January Session, 1899:

KINGSTON, JANUARY 31ST, 1899.

I have the pleasure to present herewith, in compliance with the statute of the State and the Congressional act of March 2, 1887, the Report of the Director of the Rhode Island Agricultural Experiment Station for the year 1898.

Respectfully submitted,

For the Board of Managers,

HENRY L. GREENE,

President.

RHODE ISLAND COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

KINGSTON, R. I., JANUARY 2, 1899.

HON. HENRY L. GREENE,

President Board of Managers:

SIR:—I have the honor to transmit herewith the Eleventh Annual Report of the Director of the Rhode Island Agricultural Experiment Station.

Respectfully yours,

JOHN H. WASHBURN,

President.

REPORT OF THE DIRECTOR.

A. A. BRIGHAM.

To John H. Washburn, President:

SIR:—The work of the past year has included a close consideration of the lines of investigation and of experimentation pursued by this Agricultural Experiment Station during the eleven years of its existence, in their bearing upon the present agricultural problems of the State. Most serious attention has also been given to the question of the future work of the Station, and the means, methods, and resources available for maintaining the same along lines which shall be of greatest utility and assistance in solving the special problems of practical farming in Rhode Island. It has been somewhat frequently stated that Rhode Island is a manufacturing and not an agricultural State. That the first part of this statement is true is emphatically evidenced by the numerous manufactories of diverse products, involving the investment of millions of dollars of capital, and requiring the labor of hundreds of thousands of persons. The latter part of the statement, insinuating that this is not an agricultural State, is disproved by the actual agricultural advancement of the State, especially in some sections, and by the opportunities which are offered within the bounds of these Providence Plantations for an agriculture the most progressive, the most thorough, the most economical, and the most profitable that is in this world possible. The large and varied industrial development of this State provides the very best home market for farm products right at the door of the producer. Further, one of the largest and most enterprising cities of New England is within easy reach of Rhode Island farmers, while the

railroad and shipping facilities that bring the farmer so close to the metropolis of the State, secure also rapid, effective, and economical carriage of products to the great markets, Boston and New York, which, besides their own almost limitless consumption, provide ready connection with the markets of the world. It is largely in the production of the so-called perishable products that the opportunity lies for progressive, profitable farming in this thickly populated part of our country. We will not dwell here upon the agricultural resources of the State; they are ample, as is evidenced by the success of particular farmers in various locations. The experience of these farmers shows that success in farming involves, besides the factors already mentioned, brain-work, capital, and active attention to details. In this, the smallest State of the Union, there is room for thousands more of successful specialists in farming, and for the development of the highest and most intensive agriculture. It is in this connection that the workers of the Experiment Station desire to be effectively helpful.

Four distinct lines of investigation and experimentation are developing in our Experiment Station work:

1. SOIL, FERTILIZER, AND CROP EXPERIMENTS.

The study of soils and crops, which has been followed here for over ten years, is proving of increasing value. The results already obtained, if utilized by the majority as they are by the minority of farmers of the State, would lead to an immense total reduction of farm expenses, through wise selection and rational application of fertilizers. It is full time that the farmers studied and learned more fully the real meaning of plant food. A realization by the working farmers of the value and rational use of lime, as revealed in the publications of this Station, would, if acted upon in a business-like manner, revolutionize the farming of some parts of Rhode Island, and change it from a condition of shiftless stagnation to one of progressive, profitable production. The plan of experimentation in progress in this line is outlined as follows:

Field Work.

(For plan of experimental grounds see Annual Report for 1896.)

1. Continuation of soil tests on 20th acre plots.
2. Continuation of observations on relative permanency of certain grasses upon limed and unlimed land (balance of the 20th acre plots).
3. Continuation of observations upon the growth of plants upon limed and unlimed soil.
4. Continuation of "soda substitution" experiments, and of comparison of nitrate of potash with nitrate of soda and muriate of potash.
5. Continuation of rotation experiments.
6. Continuation of trials of various forms of phosphoric acid by means of experiments in the field.
7. Continuous growing of Indian corn with and without a catch crop.
8. Acclimation of cow peas. Trials of soja beans.
9. Observations on varieties of winter wheat. (Completion of experiment in progress.)
10. Trial of varieties of potatoes, including promising foreign varieties.
11. Trials of Russian plants in coöperation with the Office of Experiment Stations, Washington, D. C.
12. Coöperative soil tests for ascertaining the need of lime, potash and phosphoric acid in various sections of the State.
13. Continuation of experiment to compare lime as a topdressing for grass with lime harrowed in before seeding.

Pot Experiments.

1. Continuation of experiments to test the probable assimilability of available phosphoric acid in form of ignited alumina phosphate, and to compare the assimilability of phosphoric acid of bone meal with that in the form of floats.

2. Continuation of experiments for the purpose of ascertaining in how far the difference in the action of nitrate of soda and of sulfate of ammonia upon the growth of certain plants is attributable to the soda or to the difference in the reaction of the soils, induced by a basic residue on the one hand and an acid one on the other.
3. Soil tests in pots for the purpose of comparing results thus secured with those obtained in coöperative experiments about the State.
4. Tests of the after-effects of sulfur when used as a preventive of potato scab.
5. Experiments to ascertain if deficiencies of magnesia exist in our soils.

Chemical Work.

1. Analysis of chemicals used in the experimental work.
2. Analyses of crops grown in "soda substitution" and phosphate experiments, and from gypsum and lime experiments.
3. Moisture determination in crops from all pot experiments, and from certain field experiments when desirable or possible.
4. Coöperation with the Association of Official Agricultural Chemists on investigations of methods of analyses, nitrogen, soils, etc., with special reference to the methods for determining the assimilability of organic nitrogen.
5. Continuation of work on methods of ascertaining the acidity of soils, including determinations of lime, total humus, free humus, acidity by titration, etc., on soils from the coöperative plots about the State.
6. Examination of miscellaneous materials sent for examination by farmers or by other divisions.

To those farmers who are especially interested in the subjects indicated, the following of our publications are especially recommended for consideration:

For information in relation to sea-weeds and their use and composition, *Bulletin 21.*

For formulas and directions for mixing fertilizers, and for information in relation to testing soils for their relative need of potash, phosphoric acid, and nitrogen, *Bulletin 34*.

For instructions in relation to the purchase and use of lime, and in regard to testing soils for acidity (sourness), *Bulletin 46*.

For the results of practical experiments with beets, barley, clover and grass, for the purpose of ascertaining the extent of the deficiency of lime in Rhode Island soils, *Bulletin 49*.

For the results of experiments on the manurial value of soda, and for trials of the effect of lime upon the growth of plants, *Annual Reports, 1893–97, inclusive.*

2. THE CULTURE OF THE WATERS.

The productive possibilities of both the inland and marine waters of the State are being carefully investigated. Vast quantities of food material for the nourishment of oysters, clams, and other useful fishes are going to waste in Rhode Island waters. Worse than this, the fishes themselves are in many locations being annihilated by practices which find their explanation only in ignorance or carelessness.

Something more fundamental or effective than legislation is required to replace the destruction and waste by preservation and utilization of the water products. The efforts of the biological division have been devoted the past season to such lines of investigation as the following:

1. The economic development of aquiculture in Point Judith Pond, with particular reference to the oyster industry.
2. The rearing of organisms in sufficient quantities for feeding, on natural food, trout which are raised for market.
3. The general biology of the white perch.
4. The effect upon developing eggs of quantitative and qualitative alterations of food supply.
5. The method of cell multiplication in the process of regeneration of lost parts.

6. The plankton of brackish water.
7. The effects of the environment upon the oyster.

Especial attention is called, in this connection, to the following of our publications:

For those persons interested in oyster culture, "Oysters in the Point Judith Pond," *Ninth Annual Report (1896);* "Point Judith Pond," and "The Starfish in Narragansett Bay," *Tenth Annual Report (1897).*

For those interested in the general utilization of waste products and waste places, and in the possibilities of the cultivation of aquatic food plants and animals, "Methods in Planktology," *Tenth Annual Report (1897);* "The Nitrogen Problem," *Bulletin 50,* and "The Clam. The Cultivation of Tidal Mud Flats," *Bulletin 51.*

The following articles are published elsewhere: "Scientific Aquiculture," in the *Report of the State Board of Agriculture, Rhode Island, 1896.* "The Problem of Marine Biology," *American Naturalist, XXVI, 1892;* and *Nature, London, XLIV, p. 625, 1892.*

3. HORTICULTURAL INVESTIGATION.

The horticultural interests of the State are deservedly receiving increased attention, and our experimentation in this connection seeks to come closer than heretofore to the chief problems of the market gardner, florist, and fruit culturist. Much of the progress of Rhode Island towards a higher and more intensive agriculture will be developed under glass. Hence we look forward with earnest anticipation to the time, which we trust is near at hand, when the State, in its wise provision of means for better experimental work in this line, shall furnish the funds for the construction of a suitable plant-house for this department. The following are among the subjects studied in the horticultural division during the past season:

1. *Apple Breeding.* An attempt to determine the influence of selecting scions from productive trees.

2. *Blooming Period.* An attempt to determine whether the blooming period of stock will influence date of bloom of scion.
3. *Cherries.* An attempt to produce a hardier sweet cherry by crossing sweet and sour varieties.
4. *Corn Mixing.* A study of the mixing of field corn and sweet corn when planted near each other.
5. *Corn Selection.* An attempt to learn whether the method of selection may influence the number of ears produced on a stalk.
6. *Beans.* An attempt to learn whether selection can develop a hardier race of beans.
7. *Gooseberry Propagation.* A trial of an unusual method of propagating.
8. *Huckleberries.* An attempt at cultivation and amelioration.
9. *Pollen, Influence of.* A study of the influence of pollen on color of melons.
10. *Stock, Influence of.* A comparison of stocks for the apple.
11. *Tree-Planting.* A study of methods of pruning young trees before planting.
12. *Strawberries.* Influence of pollen on firmness, color, size, shape, and productiveness.

We would refer those especially interested in horticultural work to the following publications of this Station:

Apple Culture, *Bulletin 37.*

Spinach, *Bulletin 41.*

Celery, *Bulletin 44.*

Lettuce, *Tenth Annual Report (1897).*

Suggestions as to Spraying, *Bulletin 52.*

The following are published elsewhere:

Asparagus Forcing, *Missouri (Columbia) Bulletin 43.*

Lettuce Forcing, *New York State (Geneva) Bulletin 146.*

Black Rot of the Cabbage, Department of Agriculture, Washington, D. C., *Farmers' Bulletin 68.*

Tomato Growing, Department of Agriculture, Washington, D. C., *Farmers' Bulletin 76.*

The Planting of Shrubbery, New York, *Cornell* (*Ithaca*) *Bulletin 121.*

Rural School Grounds, New York, *Cornell* (*Ithaca*) *Bulletin 160.*

4. POULTRY PROBLEMS.

Rhode Island's poultry problems are receiving here much needed attention and study. This State can lead, if it will, in all lines of poultry culture. Some of our poultrymen are already recognized as leaders and guides throughout America. On thousands of farms of the State land and water fowl constitute a considerable, and often the most profitable, portion of the live stock. Moreover, thousands of neglected acres of the limited area of the State, which now yield little except taxes, are well adapted to the keeping of land fowl, while numerous bodies of water, as yet not utilized, may most readily and profitably be used as adjuncts in rearing geese and ducks.

A former very important and lucrative branch of poultry farming has practically disappeared from Rhode Island. Where thousands of Narragansett turkeys were yearly raised, now few or none are successfully grown. Apparently, two of the chief reasons for this destruction have been operative: viz. carelessness in breeding and the disease known familiarly as "black head." The removal of the first mentioned cause is sought to be accomplished by the teaching in our college poultry school of the true principles of breeding as applied to fowls. An investigation of the second cause has proved that the disease is due to an intestinal parasite, which, in one of its stages, as a minute worm, buries itself in the tissues of the intestines and produces disease. There is no doubt but that this most detrimental creature needs further investigating. Considering the importance of turkey raising to Rhode Island, the expenditure of a sufficient sum of money to carry for-

ward the investigation, systematically and thoroughly, is warranted. This would involve an attempt to study out, if possible, the intermediate stages in the life cycle of this destructive organism, its hosts and habits, and experimentation to determine the effect of varying conditions upon the birds in health, and when attacked by the disease. Unfortunately this parasite is one of a class most difficult to study, and apparently beyond the reach of remedies after it has once entered the body of its victim. Probably the most hopeful line of experimentation will be found in seeking means to prevent these intestinal parasites entering the birds. Here, then, is an obstacle to turkey raising which should be removed, and which, for its removal, if it be possible, calls not for a "quack" doctor's ready-made remedy, but for study and work by experts, involving perhaps the expenditure of many thousands of dollars, which, unfortunately, are not yet available for this purpose. We invite correspondence and consultation concerning this insidious disease and shall do all that our resources possibly permit towards the solution of this vexatious problem. The lines of investigation which have been planned for the poultry division, and which have in some degree been followed during the past year, are the following:

1. *Brooder Ventilation and Heating.* An investigation into several methods of heating and ventilating brooders and brooder houses for the rearing of chickens. An attempt to secure, without injurious draughts, a continuous and sufficient supply of fresh, pure air delivered to the chickens throughout the day and night at a constant and suitable temperature.

2. *Ventilation of Fowl Houses.* An investigation and testing of various plans for ventilating poultry houses.

3. *Development of a Breed of Poultry.* An attempt to breed the so-called "Rhode Island Red" fowls to a standard, having chiefly in mind their utility as a farmer's fowl, for the profitable production of eggs and flesh.

4. *Continuation of the Experiment in Goose Breeding and Feeding.* A comparison of pure breeds of geese for market production.

5. *Perpetuation of a Variation in Breeding.* An attempt to develop an improved variety of Belgian hares.

The editions of most of the publications of this Station relative to poultry culture have by the pressing demand become exhausted. Especial mention is here made of the following references among the publications of this Station:

Experiments with Turkeys, *Sixth Annual Report.*
Diseases of Turkeys, *Sixth Annual Report.*
Gape-worms of Poultry, *Sixth Annual Report.*
Black-head of Turkeys, *Seventh Annual Report.*
(See also Circular No. 5, Bureau of Animal Industry, Department of Agriculture, Washington, D. C.)
Tape-worms in Turkeys, *Seventh Annual Report.*
Experiments with Geese, *Eighth Annual Report.*
" " " *Tenth Annual Report.*
Cross Breeding of Geese, *Ninth Annual Report.*
Fodder Crops for Geese, *Ninth Annual Report.*
Goose Breeding, *Tenth Annual Report.*

Among the publications of the Department of Agriculture, Washington, D. C., relating especially to poultry, are the following:

Fowls: Care and Feeding, *Farmers' Bulletin 41.*
Standard Varieties of Chickens, *Farmers' Bulletin 51.*
Ducks and Geese, *Farmers' Bulletin 64.*

STATION STAFF.

For carrying on the investigations of the different divisions our staff of Station workers is constituted as here indicated.

Dr. H. J. Wheeler has charge of the chemical division, with Mr.

B. L. Hartwell as chief assistant. Besides the endless analyzing which must be done in the chemical laboratory in connection with the experiments of the Station, this division is held responsible for the execution of all the details of the fertilizer inspection, according to the act of the General Assembly, which took effect July 1st. Dr. Wheeler is also in charge of the field and pot experiments, dealing with soils, fertilizers, and crops. Mr. Joseph A. Tillinghast is superintendent of field experiments. The coöperative soil tests, on farms in different parts of the State, have been under the supervision of this division.

Dr. George W. Field is chief of the biological division, which, in the year 1898, besides continued investigations of the agricultural resources of the State, has given some attention to poultry diseases. Mr. John Barlow, who has for several months assisted in this latter work, accepted, in December, the position of biologist in a western institution.

The horticultural division has been very greatly strengthened by the arrival, in September, of Prof. F. W. Card, formerly of the University of Nebraska, to serve as horticulturist. Mr. George E. Adams, assistant horticulturist, besides executing the plans of this division for the season, has aided in the coöperative field experiments, and has attended to the photographic work of the Station.

The poultry division has been carried on since April by Mr. M. H. Arnold, whose resignation, to take effect early in 1899, is most sincerely regretted.

Mr. Nathaniel Helme, meteorologist, has added another year of faithful observation and accurate attention to the details of his division.

Miss B. E. Bentley, stenographer, continues her effective and very helpful assistance in the office work of the Station.

Some of our Station workers must devote a large amount of time to educational duties in the college, which, though rendered necessary by the limitations of our funds, is not conducive to the most effective investigational work.

BUILDINGS.

The Station shares, to a considerable extent, in the advantages secured to the institution of which it is a part through the construction of a dairy barn, a storage building, and an addition to Taft Laboratory, during the past year. The storage room, thus provided through the wise action of the General Assembly, relieves to some extent the crowding of the little old barn on the plain, which has been the only covering available for the machines, supplies, products, and indoor work of the field experiments, and which remains a very poor apology for the building urgently needed by the Station for the proper conduction of the field work.

The past year has shown the inadequateness of the heterogeneous little poultry houses for experimental purposes, and emphasizes the need of a plain but capacious poultry building, which, though not costly of construction, should be ample in its proportions, convenient in its arrangements, easy of control in all its conditions, and thoroughly adapted to the special purposes of investigation and experimentation in the breeding, feeding, rearing and numerous other features of poultry culture.

Considering that the Experiment Station is maintained by national funds, and that only 5 per cent. of these funds in any one year can possibly be used for construction purposes, and that all of these funds are required and should be used for the direct purposes of experimenting; and, further, considering the importance of the poultry interests of the State, it seems exceedingly fitting that the State should supply a building so much needed, and thus provide for the most advantageous and effective use of the United States funds available for experimentation in poultry culture.

FERTILIZER INSPECTION.

According to the act of the General Assembly, passed March 1st, 1898, the control of the fertilizer inspection for the State, commencing July 1st, was placed in the hands of the Board of Managers

of the R. I. College of Agriculture and Mechanic Arts, who, by vote, entrusted the matter to the experimental department of the institution, and instructed the Director of the Station to arrange for the execution of the details of the fertilizer inspection by the chemical division. Through the courtesy of the Secretary and members of the State Board of Agriculture, the transfer of the business to the college was promptly effected early in July. One bulletin had been published by the Board of Agriculture in June. The reports of analyses of fertilizers remaining unpublished on July 1st, which were turned over to the Board of Managers of the college, were immediately published in Bulletin No. 48, and promptly distributed. The fertilizer manufacturers whose fees for the year were still unpaid, were notified, and in almost every instance they responded promptly by paying their dues to the State.

THE ADULTERATION OF FEED STUFFS.

Many samples of feeding stuffs sold in the State have been sent to the Station for examination. Numerous letters and personal requests have also been received bearing upon the subject, which indicate a very strong dissatisfaction among purchasers of the feeding-stuffs offered for sale in Rhode Island. The quality of the samples received, particularly of cotton-seed meals, warrants the suspicion of the dairymen and others who find it necessary to purchase concentrated feeds. Some farmers have stated to us that they found the feeds purchased lacking in milk-producing qualities, and have urged us to examine the materials, because they found it necessary in some cases to feed double the quantity formerly used to produce a given quantity of milk. Several analyses of cotton-seed meal showed adulteration by means of finely ground cotton-seed hulls to such an extent as to reduce the value of the feeding-stuffs fully one-half. A cursory examination of the business shows that Rhode Island has become the dumping ground for adulterated feed products, and that the feed laws of Connecticut, Massachusetts, Maine and Vermont, while they protect

the purchasers in those States, tend to drive the adulterated feeds into this corner of New England. The remedy is to be found in so regulating the business that purchasers can buy their feeds on a certified and guaranteed valuation.

PUBLICATIONS.

The publications of the Station issued during the past year include the report of the Director *pro tem.* for 1897, and the following bulletins:

No. 47. Lime, Nitrogen, and Soda.

No. 48. Analyses of Commercial Fertilizers.

No. 49. Liming in Rhode Island. Legumes.

No. 50. The Utilization of Waste Products and Waste Places. The Nitrogen Problem.

No. 51. The Clam. The Cultivation of Tidal and Mud Flats.

The annual report for 1897, although not fully published and distributed until December, 1898, disposes of a mass of material and helps to clear the way for advanced work. The labor in connection with the publication of this report has taken the time of our force during the season to such an extent as to interfere considerably with the proper work of the year. A special and successful effort has been made to prepare the annual report for 1898 promptly, and its reasonable size warrants the hope that it may be printed and distributed for effective perusal and consideration by those interested before the opening of another season of farm operations.

Further, it may be stated here, incidentally, that the reports and bulletins of the Department of Agriculture are available to those interested in agriculture in Rhode Island, and any one who so desires can secure from the U. S. Department of Agriculture at Washington a monthly list of the publications of that Department.

CONCLUSION.

In concluding this report the Director desires to express to the Board of Managers and to the President of the College his sincere appreciation of their prompt approval of plans and cordial support of measures taken for the advancement of the work of the Station. The faithful and hearty coöperation of the Station workers has been an exceedingly pleasant and effective factor in the success of the year's labors.

Among the very numerous letters received and answered during 1898, many have expressed kindly appreciation of results accomplished and assistance rendered by the Station. The candid criticisms of practical, thoughtful farmers, shown in correspondence and consultation, have been most valuable incentives to earnest investigation and thorough research. It is hoped that the farmers of the State will in the coming year, in larger numbers than ever before, visit the Station and inspect the work in progress.

The reports of heads of divisons, and others in charge of various lines of experimentation, are made a part of this report, and herewith respectfully submitted.

BIOLOGICAL DIVISION.

GEORGE WILTON FIELD.

The work of the biological division has been carried on both at its marine laboratory at Point Judith Pond and at the Experiment Station. In regard to the nature and purpose of the work at the pond there appears to be a popular and general misconception ; for that reason especial attention should be called to the fact that those who have charge of the general work of the Experiment Stations prescribe carefully the nature of the work to be undertaken, and that they especially avoid the actual development and execution of economic enterprises. The function of Experiment Station work is to ascertain the feasibility, and to suggest plans for work; but it cannot undertake to execute plans for development of projects or territory for the benefit of special individuals or communities. The prevalent idea that the purpose of our work at the Salt Pond is to again stock the pond with shell fish is based upon a misconception. The real purpose is to ascertain why the pond is not producing the food material (fish and shell fish) which it formerly did, and which it is still capable of doing under proper conditions. These conditions are extremely complicated, and we are studying them so far as our means allow.

The work is carried on under two heads: (1) the study of the oyster as it exists in the pond; (2) the study of the pond itself; the nature and changes of the water under different meteorological conditions; the relations between the water of the pond and that entering from the adjacent water-shed and the ocean; the course of the currents and their influence upon the bottom; the reciprocal

relations between the fauna and flora of the pond; this latter involves study of all the animals and plants found in the pond, and of the conditions under which each lives; the effects of increased or diminished salinity of the water, of the temperature, etc.; of the feeding and breeding habits of all the animals, including not only those of immediate economic importance (e. g. oyster, clam, white perch, herring, flatfish, crab, etc.) but also those which, though of no apparent immediate importance, are, as food, indispensable to the growth of the larger forms. One of the most important points thus far ascertained, from study of the conditions in the pond, is the conclusion that the oysters in certain positions are killed by the deposition of sediment. This silt, brought down by the river, is carried suspended in the water until the motion of the water ceases; the silt then settles. Those oysters which are lowest are covered; they die and the gases of their decomposition together with the gases (especially H_2S) generated by the oxidizing vegetable substances in the mud, either deposited upon or grown in the mud, poison the neighboring oysters, and the result is the depletion of large areas. It is believed that a permanent breach, of sufficient capacity to furnish an outlet for the water which enters the pond from the water-shed, and of such a width as will scour, can be maintained at a cost which will be many times offset by the increased economic yield of the pond. The proper method of carrying out this work can only be determined by careful experimentation. The limited resources of the Experiment Station fund preclude any immediate work upon the breach. Nevertheless the physical conditions at work at the breach have been under observation for three years, and experiments and plans for improvements have been formulated, and it remains for those interested to say whether such work shall be entered upon. It seems eminently proper that the town of South Kingstown should appropriate a small sum for defraying the cost of some preliminary experiments.

At the Experiment Station laboratory work has progressed on an extensive work upon the oyster, including its life history,

œcology, comparative anatomy, and histology, methods of cultivation, etc., etc. Two bulletins in the series on the "Utilization of Waste Products and Waste Places;" I. The Nitrogen Problem; and II. The Clam; the Cultivation of Tidal Mud Flats, have been distributed. The productive capacity of the department was greatly enhanced by the appointment of John Barlow, B. S., as assistant biologist. Very soon after entering upon his work here, in September, he was called to an important college position in Wichita, Kansas, and no funds were available for retaining him. His careful, conscientious work has left its impression here. Under my direction he undertook the consideration of poultry pathology, working especially on the "Roup," and on a remarkable epidemic which appeared among the fowls of C. W. Wilcox. Although the work is very incomplete, it has been thought best to print immediately the results upon "Roup." The report upon the epidemic is still more incomplete, but the material is in such shape as to be available for future study, and it is hoped that a full report may be forthcoming.

NOTES ON ROUP IN FOWLS.

JOHN BARLOW.

The term "Roup," as applied to disease in fowls, is scarcely scientific. To what disorder the term was first applied is not known, and the origin of the word itself is uncertain; it is possibly a variation of *Croup*. Most articles which appear in agricultural papers upon this subject use the word Roup very indefinitely. Judging from the great variety of symptoms and different courses of disease spoken of under this name, it would seem to cover all diseases which manifest themselves by a discharge from any of the mucous membranes of the head. In Europe diseases similar to this have been termed fowl diphtheria.* It is possible that there are several diseases which result in inflamed and purulent mucous membranes. But little scientific work has been done to ascertain the cause of the disease. Future investigation will increase our knowledge on this point, and probably the disease which we now call Roup will prove to be a class of diseases having at least one point in common, viz., catarrhal inflammation of the mucous membranes of the head.

This disease, or class of diseases, is a very important one. It results in the loss of thousands of dollars annually to the poultry raisers of Rhode Island alone. In some localities it is so fatal that all profits are swept away, and the business has been abandoned by many farmers for this cause. One writer states that 80 per cent. of the deaths among fowls in Canada arise from this cause. Epidemic diseases which prove fatal to large numbers of

* Schneidemühl. Vergleichende Pathologie, Leipsic, 1896, p. 57.

fowls in a short time indeed attract much more attention, though the total number of deaths in the long run is far less. Roup, then, is a very insidious disease, is widely spread over the country, and is slowly reducing the numbers in many flocks. The course of the disease is slow, and it sometimes becomes chronic and continues for a long period. Many fowls are affected and are held out of use for a long time, and probably never regain their full vigor. Thus, in addition to the loss by death, the indirect loss, through reducing the total of poultry products and rendering useless many animals, is very great, as Dr. Moore has pointed out. In addition to this the loss is increased through the diminished vitality of the breeding stock, resulting in weaker and less productive flocks.

The disease is not only prevalent in this country and Canada, but many reports appear in European journals of a disease similar in general nature to that occurring in this country. It affects not only chickens, but pigeons, pheasants, and other birds. (Schneidemühl.)* (Stevenson.)†

It usually affects young fowls. Often it is so destructive that the profits of raising are entirely consumed. Sometimes half the chickens hatched die from this cause. It is not, however, confined to young chickens, though they suffer most. Full grown fowls are subject to its ravages. The progress among the old hens is slower, but by it they are made useless as layers, and it is doubtful if they ever regain their full strength. It is much more prevalent in the fall and winter. This is probably due to the cold weather.

The first symptoms which are apparent, without careful examination, are moping, ruffled feathers, poor appetite, and "going light." These are followed by inflammation and watery discharges from the nose and eyes. If, however, a fowl be very carefully watched from the outset of the disease, these symptoms will be found to be preceded a number of days by the appearance of minute patches of white exudate in the throat and nasal

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* Schneidemühl. Vergleich. Pathologie.

† Dr. H. A. Stevenson. Jour. of Comp. Med. and Vet. Archives, July, 1898.

passages, and by a rise of temperature of one or two degrees Fahrenheit. It is usually ten or twelve days from the inception of the disease until the well marked symptoms make their appearance. (Schneidemühl experiment.) At the outset the exudate is a watery secretion possessing scarcely any odor, and the inflammation is rather local. It may be one eye or one nostril which begins to swell and exude. As the disease progresses the secretion undergoes a change; it becomes more viscous, and resembles pus, also, either from coagulation or from drying, it hardens into a crusty mass. This mass adheres very tightly to the surface and can be scraped away only with difficulty. Its removal from the throats of some fowls leaves bleeding spots in its place. The adjacent membranes become greatly inflamed and swollen. The secretion continues and accumulates, sometimes filling the eye, and drying on the surface prevents the natural removal of the secretion. This results in the formation of a spheroidal mass of yellowish, cheesy matter which closes the eye completely. Where the lining of the air passages is affected in this way, the mass collects within the nasal chambers, increasing the inflammation and causing large swellings below the eyes. Bacteria collect in this mass and putrefaction takes place, resulting in the production of very foul smelling gases. After this encrustation has remained adherent to the mucous membrane some time it is sloughed, carrying with it the superficial layers of the epithelium. Where the mass has dried tightly to the lids of the eye, so that it is not removed, the diseased mucous membrane is prevented from healing, and thus the eye is permanently closed. In some cases this affects both eyes. In the nasal chambers the secretion is often held in this way.

All these lesions are accompanied by a permanent rise of temperature, varying from one to three degrees. The digestive system is very much affected, the appetite is small, and the fowl grows very light, has difficulty in finding its food, especially when both eyes are affected, and death is probably due in many cases to impaired nutrition.

Great variation is noticed in the virulency of the disease. Usually it claims only an occasional victim from the flock, many victims recovering. At times outbreaks are reported from various quarters, and the symptoms described are in a general way similar to the more chronic form. The progress of the disease is very rapid in these epidemics, and is often very destructive, sweeping away whole flocks and entailing heavy losses.

The cause of the disease is obscure. Many poultry raisers maintain that it is only the result of a cold which has developed into catarrh, and is in no way contagious. They hold that it is the result of exposure to cold draughts and damp weather. Their position is sustained by the great improvement noticed in affected fowls as soon as they are placed in warm quarters and well supplied with food. It is also noticed that fowls which are accustomed to open air and wide range are seldom affected.

On the other hand there is abundant proof that the disease is due to bacteria. Fowls in localities never contaminated by the germ are doubtless subjected to as many draughts and other exposures as in places where the disease prevails. And instances can be cited where flocks previously entirely free from the disease have produced numerous cases after some infected fowls were put with them. The facts to be spoken of a little later, regarding the method of contagion of the disease, leave no room to doubt that the disease springs from a bacterium.

The nature of the germ is not yet determined. Some authors maintain that it is identical with the one which produces diphtheria, known as the Klebs-Loeffler bacillus. The habits and nature of this organism are well known. It is a short rod-shaped bacillus which shows great variation in different parts of its body for absorbing color. This gives the stained preparations a very irregular appearance. Most bacteria stain uniformly, looking like dashes, periods, and commas in the microscopic field. But these germs have dark and clear spots, giving them a very ragged appearance. In addition to this the bacilli have characteristic positions and methods of arrangement on the slide which help to give the

appearance to the preparations which are easy to recognize. These peculiarities, however, only appear in cultures made in blood serum tubes, and it is by the use of these tubes that the bacillus is identified. The germ can be separated from any others with which it is mingled, by placing cultures upon serum in an incubator. After six or eight hours the Klebs-Loeffler bacillus will show a very abundant and characteristic growth. No other bacteria grow so rapidly on this medium. The form of the growth also is characteristic. When these features are noted in cultures taken from a suspected case of diphtheria, the diagnosis is very certain, and is absolutely confirmed if an innoculation produces death in guinea pigs within four days.

Now it is a very important matter if the bacteria which cause a widespread disease among fowls in every section of the country are identical with the bacteria which cause so dangerous a disease among human beings. This is firmly maintained by many authors, and with some show of reason. Cultures from the exudate of diseased fowls do produce a growth in serum tubes very similar to that produced by the bacillus of diphtheria, and slide preparations also exhibit many of the characteristic features of the same bacillus. But so far as the writer knows no one has demonstrated the identity of the two bacilli. I have made some careful tests on a number of fowls, but have not succeeded in identifying this germ. Cultures in serum show no growth for twelve hours, and often it is twenty-four hours before the growth is large enough to be easily seen; neither do the bacilli, when stained, present the well known appearance of those of diphtheria.,

Dr. Moore has made a careful study of the bacteria found in Roup. He has succeeded in separating several varieties, but does not speak of finding one which resembles the Klebs-Loeffler bacillus.

It would be inevitable, if the germs which produce the two diseases were identical, that the outbreak of Roup among fowls would be followed by the appearance of diphtheria among men. But there has never been offered any such "correspondence" between them. Cases have been reported, however, which tend

to show that this disorder may develop into diphtheria. An interesting case was reported several years ago from Lebdon. (Archives de Medicine et de pharm milit, 1892, p. 204. Centralblatt für bacteriologie, XIII, p. 730.) An epidemic of diphtheria broke out among the soldiers stationed at that place; two cases were fatal. Very soon after diphtheria made its appearance among the fowls tended by one of the soldiers, and resulted in several deaths. It was subsequently found that one soldier, who brought the disease, had come from another post at El Aricha, and that among the fowls of this place a disease was prevalent similar to the one which appeared in Lebdon. The author of the article thinks the disease was contracted by the soldier from the fowls at El Aricha, by him transferred to Lebdon and given to the men and fowls. Other cases are reported from this country and Europe; their great rarity and lack of careful investigation gives them little weight. It is to be lamented that the subject is in so uncertain a state of knowledge, and it is possible that on further investigation cases of this dreaded disease, whose origin seems mysterious, may be traced to fowl diphtheria. It is not a disease one would wish to touch carelessly, and, until positive evidence is forthcoming, caution in handling the affected chickens is recommended; pathogenic bacteria are not safe playthings, and their effects are always full of danger.

Dr. Moore has examined and described a bacterium which he has found invariably present in several cases of Roup examined. It is very similar to the germ of chicken cholera, described by European authors. But from his account it is evident that this is not the cause of the disease, since, where innoculated into healthy fowls, it produced no results. So, although we are certain that the disease is due to bacteria, its nature is not by any means known.

CONTAGION.

In speaking of the cause of the disease we indicated that the disease is easily communicated from flock to flock, and from indi-

vidual to individual. Numerous cases have been reported where healthy flocks have been infected by adding to their number one or more fowls affected with the disorder.

Experiments abundantly show that the disease is conveyed by contact from fowl to fowl. Dr. Stevenson, of London, Ontario, has given the matter considerable attention. He reports that the disease may be conveyed by confining the fowls for three or four hours together in a bag. In his article in the *Journal of Comparative Medicine*, Philadelphia, July, 1898, p. 451, he states that he has often conveyed the disease in this manner. He gives his opinion that the disease arises from the Klebs-Loeffler bacillus, but, unfortunately, does not detail any of his experiments to establish this point.

With a view to definitely determining the method of the contagion, I recently performed several instructive experiments. A fowl was selected, perfectly healthy and strong, and to its eyes was applied the discharge from the eye of a fowl afflicted with the disorder. The fowl was kept and watched with care. After ten days the disease manifested itself. Again, to determine the method by which the disease was conveyed ordinarily from one to another, two well fowls, a hen and cock, were confined in a small pen with a chicken badly affected by the disease. The three fowls were obliged to eat and drink from the same dishes, and were seen to sit together upon the roost. After twenty-one days the disease made its appearance in the healthy hen, and several days later the cock also contracted the disorder. These experiments, repeated in various ways among poultrymen have established the point that the disease is conveyed by contact.

TREATMENT.

Roup is amenable to curative remedies, and with wise treatment the ravages of the disease could be greatly lessened. Most important of all is the necessity of preventing the spread of the disease. There should be in connection with every farm a pest-house, where all those fowls affected may be isolated and treated.

It is unwise to kill all the fowls affected, since careful treatment will usually cure. After the fowls are cured they should be kept isolated for a time, to be sure that all germs are dead. And when any additions are made to the flock they should at first be quarantined for many days, until it is certain that they are free from the disorder before they are allowed to mingle with the other fowls. In addition to this, *fowls once affected should never be used for breeding.* It is by no means certain that the disorder is hereditary, but the appearance of the disease among very young chickens leaves ground for suspicion on this point. But more important than this is the inevitable weakening of the vitality and the consequent weakened offspring.

The therapy of the disease consists in placing the chickens in comfortable quarters, and seeing that they secure an abundance of rich food. It is reported from Washington, D. C., and Raleigh, N. C., that many cases of the disease were cured by the use of these means alone. In the outline of the etiology we indicated a course of several stages with attendant symptoms, and after passing through this, under favorable conditions, the patient recovers. The disease may be arrested, in the early stages, by warmth and care.

A few simple remedies are recommended. An antiseptic wash, such as dilute carbolic acid, $\frac{1}{1000}$ solution of ($HgCl^2$) corrosive sublimate, or lysol. Kerosene is often of use as a local remedy. Besides this, Hege (Bulletin No. 152, N. C. Agricultural Experiment Station) recommends the use of Epsom salts as a purgative dose; others recommend oil or turpentine for this purpose. Where the exudate collects in the eye it should be carefully removed, and the eye washed with an antiseptic solution, e. g. Peroxide of Hydrogen, 3 per cent. aqueous solution. Where a swelling indicates the collection of matter in the nasal chambers, they should be opened, and usually a large amount of a putrid mass may be removed. All these pieces should be burned, as they are the means of contagion. Mr. Wilcox, a successful poultry raiser of Kingston, R. I., reports that he has had no deaths at all from Roup for many years. His method is to remove any exudate

which may be found either in the eyes, throat, or nasal passages, and to keep the fowl free from exposure. Doubtless many of the deaths attributed to this disease arise from improper nutrition, or actual starvation. The sick fowls are stupid and weak, and are unable to secure their share of the food. Thus, in their weakened condition, when abundance of food is most necessary, they are improperly fed, and, perhaps, get nothing at all. If one eye is blind they can see much less food than formerly, and are outstripped by their more healthy mates; when both eyes become closed, as often happens, they are unable to find food at all, and will certainly die very soon if no assistance is given. When these collections of matter take place in the nasal chambers, respiration may be seriously interfered with. By the use of even simple means there is no doubt that the loss from this disease can be greatly lessened.

HORTICULTURAL DIVISION.

FRED W. CARD.

The work of the horticultural department during the present year has been comparatively unimportant, the active connection of the present horticulturist with the Station having begun September 1.

A few minor experiments, outlined from a distance at the beginning of the season, were carried out by the assistant horticulturist. These clustered largely around questions of plant breeding. Among them were experiments in the selection of sweet corn, designed to determine if a given definite line of selection will tend to increase the number of ears per stalk. A question relating to the mixing of sweet corn and field corn was also taken up. Longfellow flint corn and several varieties of sweet corn were planted in close proximity. Careful observations at husking time failed to show any kernels of the sweet corn type on ears of the flint corn, though yellow kernels were very numerous on the sweet corn ears, being most abundant on ears taken from rows next the yellow corn. These yellow kernels were much lighter in color than those of the pure variety, being intermediate in character between the sweet and the flint corn. Yellow kernels which appeared on ears of Stowell Evergreen were usually dented, but were not when found upon other varieties. It remains to be seen whether pollen of sweet corn was able to fecundate pistils of yellow corn, without exerting an immediate influence on the character of the kernel.

Pursuant to the question whether pollen exerts an immediate

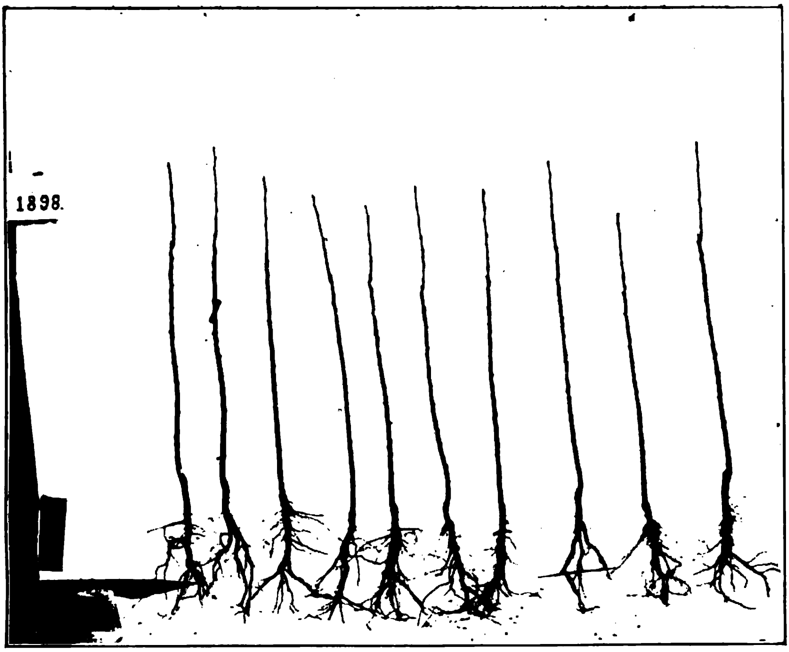


FIG. 1. TREES RECEIVED AS WHIPS.

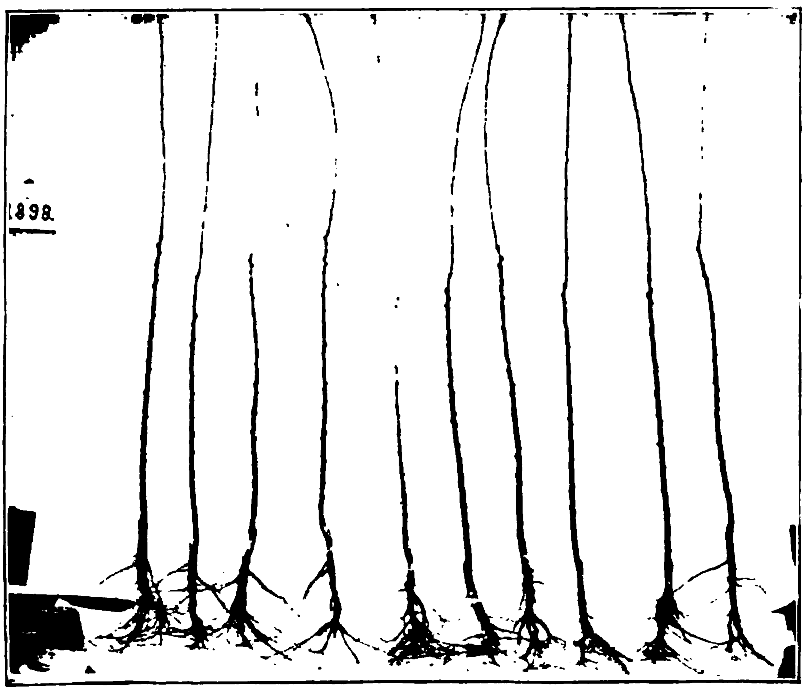


FIG. 2. LIMBED TREES PRUNED TO WHIPS.

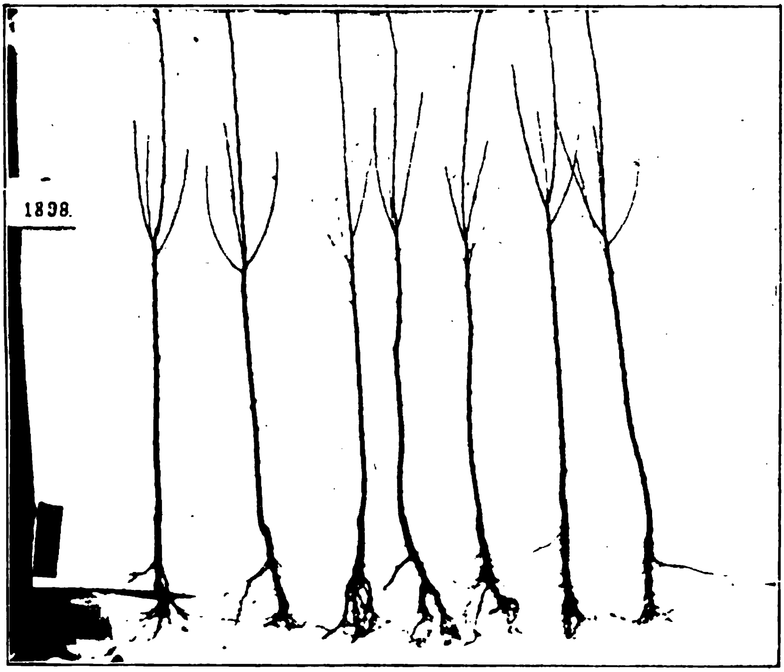


Fig. 3. Branches cut back half.

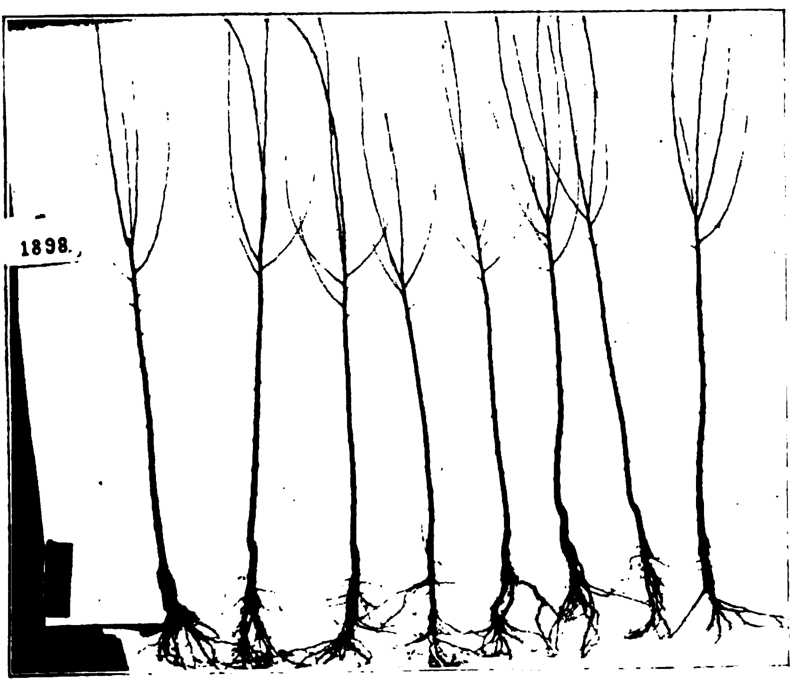


Fig. 4. Untrimmed.

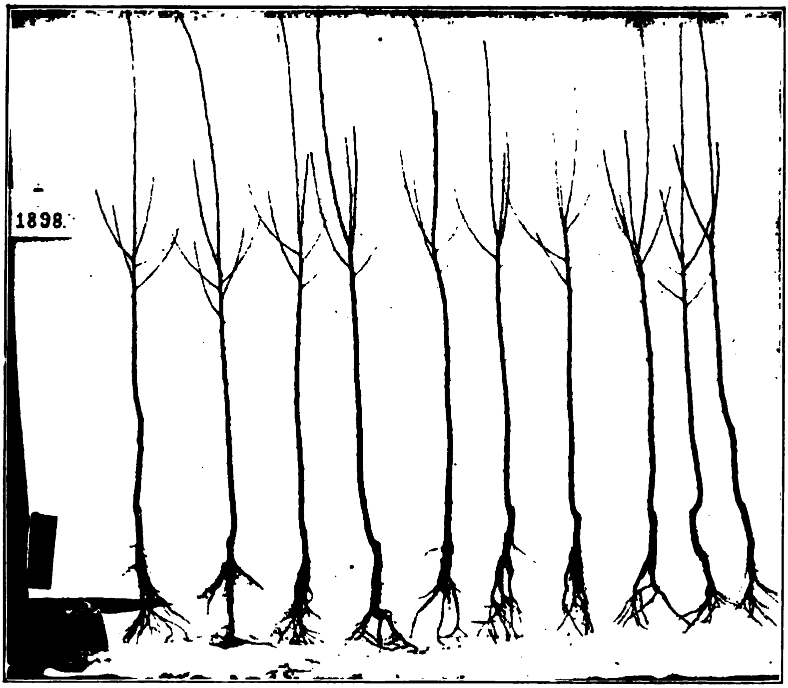


FIG. 5. ROOTS CUT BACK HALF.

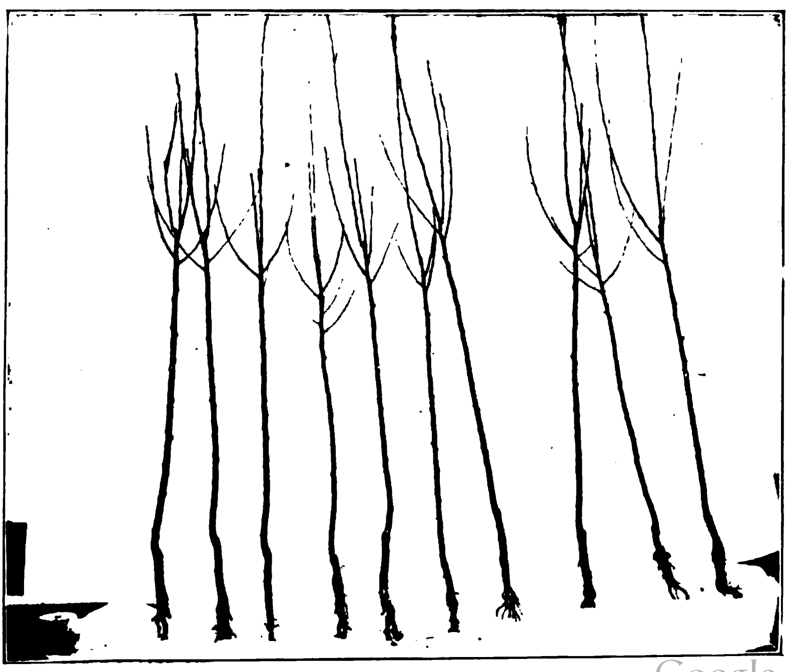


FIG. 6. ROOTS CUT VERY SHORT.

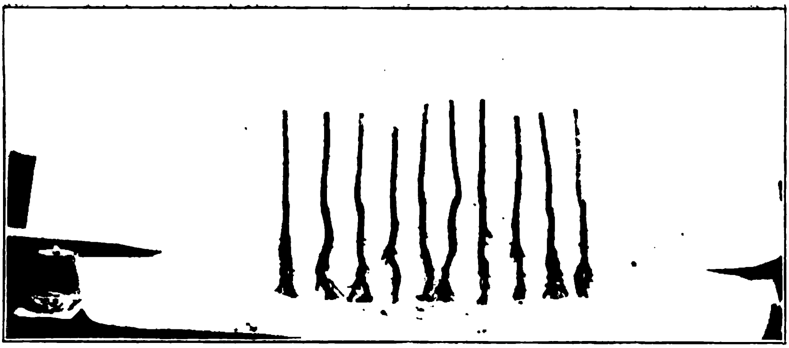


FIG. 7. STRINGFELLOW METHOD.

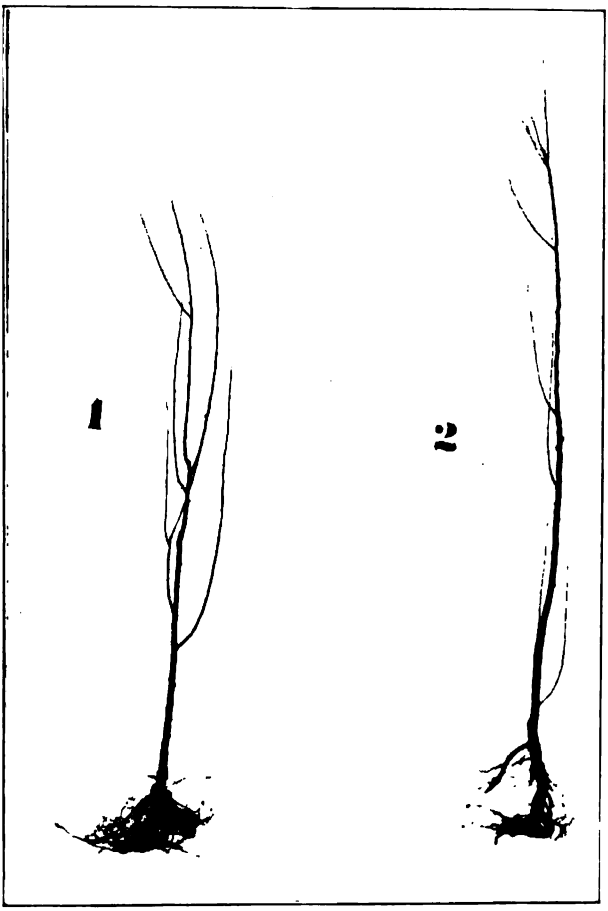


FIG. 8. FIRST YEAR'S GROWTH.

1.—Tree received as whip. 2.—Tree pruned to whip when set.

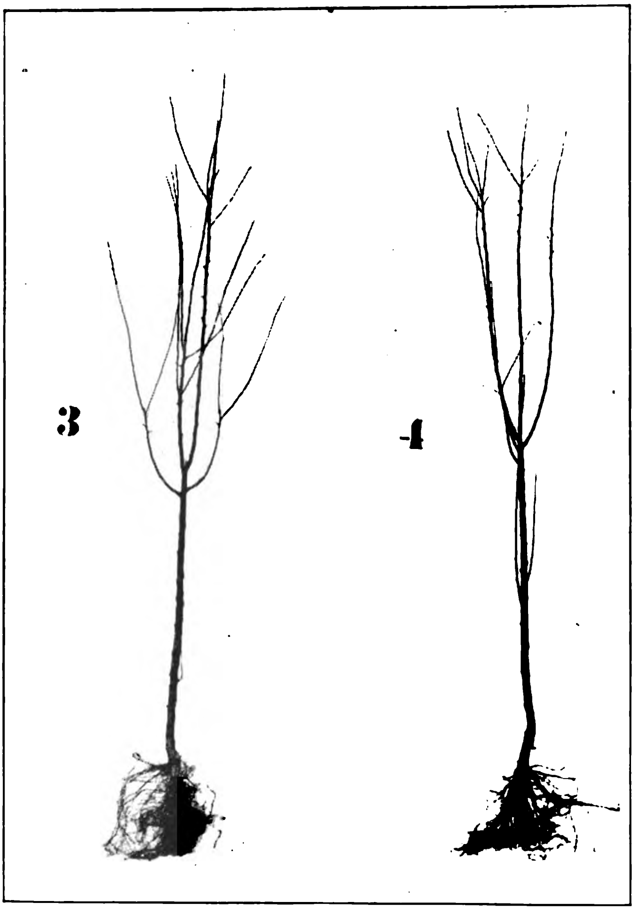


Fig. 9. First Year's Growth.

3.—Branches cut back. **4.—Untrimmed.**

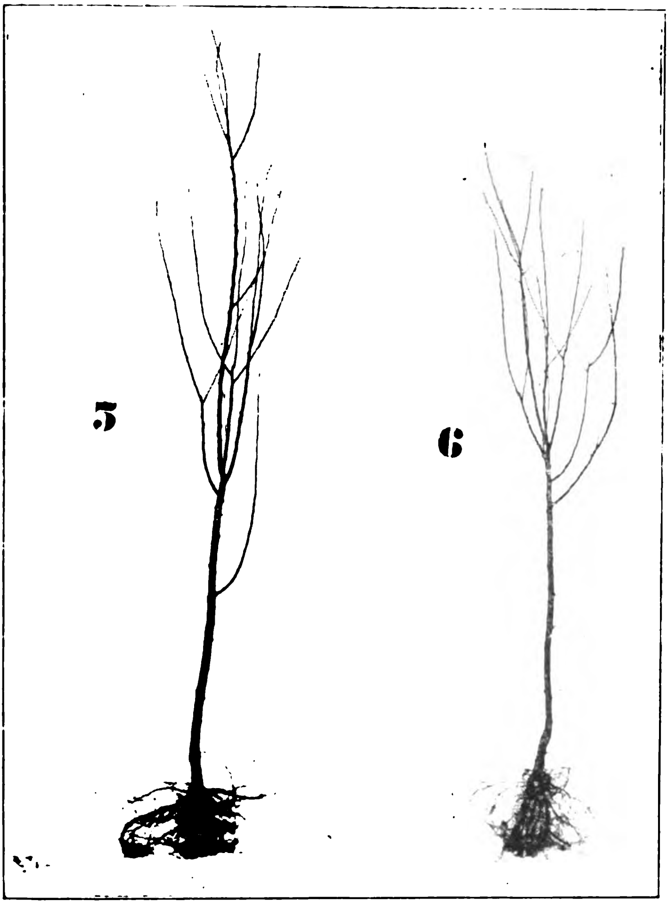


Fig. 10. First Year's Growth.

5.—Roots untrimmed. 6.—Roots cut back half.

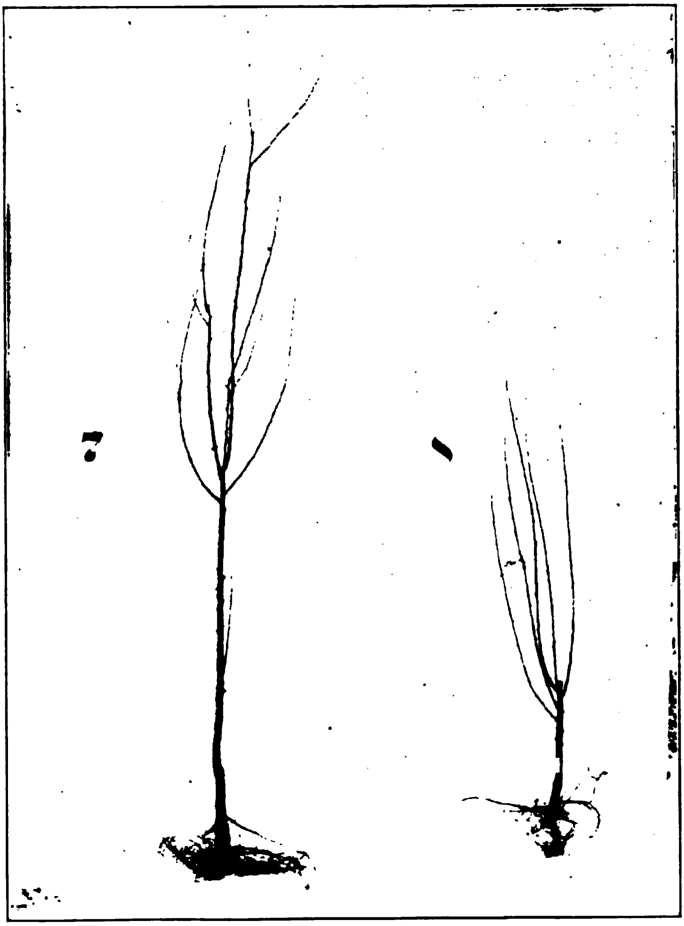


Fig. 11. First Year's Growth.

7.—Roots cut very short. **8.—Stringfellow method.**

influence on the character of the fruit among the cucurbits, crosses were made between pink and yellow fleshed watermelons. Only two fruits were secured as a result of these crosses. They gave no evidence of having been influenced by the pollen applied, the color of the flesh being the same as in others. One such crossed specimen had a decidedly poor flavor, apparently resembling pumpkin. Had this fruit been taken from vines growing near pumpkins, it might well have been brought forward as evidence that pumpkins spoil watermelons. Yet this flower had been carefully covered and had received only pollen from another watermelon. The pumpkin flavor must have been due to some other cause than pumpkin pollen coming in contact with the flower from which the fruit developed.

PRUNING TREES WHEN PLANTED.

The question of how to prune a tree before planting is an important one, and one upon which much diversity of opinion exists. Experiments bearing upon the point had been in progress in Nebraska for some time, and certain lines were inaugurated here in the spring of 1898. The outline for work was as follows, two-year limbed apple trees being used in all cases except for No. 1. The variety used was Northern Spy, ten trees being planted by each method:

1. Two-year whips. (Fig. 1.)
2. Limbed trees pruned to a whip when set. (Fig. 2.)
3. Branches cut back one-half, leader left. (Fig. 3.)
4. Untrimmed. (Fig. 4.)

In all the above the roots were left untrimmed, unless injured or decayed at the end, in which case they were cut back to sound wood.

5. Roots untrimmed. (Same as Fig. 3.)
6. Roots cut back half. (Fig. 5.)
7. Roots cut back closely. (Fig. 6.)

In these three sets the branches were cut back about one-half and the leader left untouched.

8. Stringfellow method, the roots being cut back to a mere stump one or two inches long, and the tree to a trunk about a foot high. (Fig. 7.)

The two-year whips were intended to be trees grown as whips in the nursery, that is, without branches. Apparently they were not such trees, but limbed trees which had merely been pruned to whips before being shipped. The tops had been cut off at about three and a half feet from the ground, thus differing from other trees in the experiment, the leader being left untouched in all others, except those pruned by the Stringfellow method. (See Fig. 1.)

Measurements of the amount of wood growth made during the season were taken October 21, notes upon their general appearance having been previously made.

1. *Trees Received as Whips.* These made an excellent growth, and promise to become good trees. The average number of branches per tree is seven, and the average aggregate growth per tree, 16.35 feet.

2. *Trees Trimmed to Whips When Set.* These trees have developed a very undesirable form. A cluster of branches appears at the extreme top of the tree, six feet or more from the ground. Below that is a long naked stem, comprising the previous season's growth, below which other limbs issue from the older growth. In one or two cases a new shoot emerged, very late, from this bare portion of the stem. The lower limbs are often but two or three in number, and borne on one side of the tree, with one or two others emerging just at the ground. The average number of branches per tree is eleven, and the average aggregate growth per tree, 16.78 feet.

3. *Trees With Branches Cut Back Half.* The character of growth somewhat resembles that on trees trimmed to whips, no branches having emerged on the leader from last year's growth. The character of growth below, starting from the shortened

branches, is so much better that they are really good trees. The average number of branches per tree is fourteen, and the average aggregate growth per tree, 20.5 feet.

4. *Untrimmed Trees.* In these trees the branches are long and willowy, making somewhat top-heavy trees. The average number of branches per tree is thirteen and one-half, and the average aggregate growth per tree, 15.7 feet.

5. *Roots Untrimmed.* Excellent trees. Average number of branches, 16.2. Average aggregate growth per tree, 25.1 feet.

6. *Roots Cut Back.* Good trees, very similar in appearance to those with roots untrimmed. Average number of branches per tree, 13.3. Average aggregate growth per tree, 19.1 feet.

7. *Roots all Cut Away.* Every tree lived and made a good growth. Their success is remarkable. Average number of branches per tree, 13.6. Average aggregate growth per tree, 18.26 feet.

8. *Stringfellow Trees.* All trees lived and made a most excellent growth. The shoots are strong and vigorous, and the habit excellent. Average number of branches, 7.2. Average aggregate growth, 16.4 feet.

One representative tree from each lot was taken up and the roots examined. The root-growth was excellent, starting largely from the base of the main stem, with fine fibrous ones from the cut ends of the old roots. The Stringfellow tree and the tree pruned to a whip seemed to have poorest roots, those with branches shortened and roots untrimmed being among the best. These trees are shown in Figs. 8, 9, 10 and 11.

The growth of the trees, on the whole, has been most admirable. not a tree perished, and nearly every one made a good growth. They were planted in moist soil, and the climate is evidently especially favorable for tree-planting. In the dry climate of Nebraska the results were quite different. In 1897 fifty per cent. of the trees pruned by the Stringfellow method died, while all others lived. In 1898, trees so treated did much better, the season having been more favorable, but many of the trees having the roots cut away and the branches merely shortened were un-

able to survive. The practical deductions are the same in either case, for in Nebraska, as in Rhode Island, the best growth resulted from leaving all sound roots undisturbed. In Nebraska those trees which had the branches cut back one-half seemed to be most desirable during the first year, but at the end of the second year those planted wholly untrimmed appeared to be somewhat better.

EXPERIMENTS IN PROGRESS.

Among experiments recently begun may be mentioned an attempt which is being made to regenerate certain old peach trees now growing on the Station farm. These trees are located on low ground, where the buds fail to survive the winter. They are now surrounded by a clover sod, and have made very poor wood-growth. Some are being laid down and covered for winter protection, and in the spring are to be tilled and fertilized. It is improbable that such trees, located as they are, can ever be made profitable, but the question at issue is whether it is possible to get any return under such conditions.

Experiments are also being inaugurated, in so far as our very limited resources will permit, in connection with the growing of lettuce under glass, and in the forcing of rhubarb and asparagus.

CHEMICAL DIVISION.

H. J. WHEELER.

On account of the varied character of the work of the chemical division, it is deemed best to discuss it topically, as heretofore.

Fertilizer Inspection.

In May, 1897, the law regulating the sale of commercial fertilizers was so amended as to permit the State Board of Agriculture to have the work of analysis done wherever the board should decide; provision was also made for the publication of the analyses as bulletins of the board. In consequence of a movement on the part of the farmers of the State, the law regulating the sale of commercial fertilizers was again amended at the January session of the General Assembly, in 1898, and the work of inspection and the publication of the analyses transferred to the Board of Managers of the Rhode Island College of Agriculture and Mechanic Arts. Subsequently the board of managers assigned the detailed supervision of the inspection to the chief chemist of the Station. The transfer of the inspection did not go into effect until July 1, 1898, the date of the expiration of the contract previously entered into by the State Board of Agriculture.

Upon again assuming the work it was found that a large number of analyses were still to be published. These were accordingly issued as a part of Bulletin No. 48 of this Station, the analytical work, compilation of results, calculation of commercial valuations, etc., having been properly credited to the State Board of Agriculture and its chemist.

Upon comparing a list of the brands of fertilizers and the amount of fees already received by the General Treasurer, with a list of the brands of goods found on sale by the collector, it was learned that fees to the amount of several hundred dollars were still due. The correspondence growing out of the collection of these fees was in some cases quite extensive.

At the 1897 meeting of the Association of American Agricultural Colleges and Experiment Stations, the chief chemist of the Station was appointed by that body as chairman of a committee on uniform fertilizer legislation. This committee was instructed to act, conjointly with a similar committee appointed by the Association of Official Agricultural Chemists of the United States, for the purpose of taking steps to secure greater uniformity in the laws regulating the sale of commercial fertilizers in the several States of the Union. A meeting of the two committees was held in Washington, D. C., in October, 1897. Subsequently three subcommittees were appointed to confer with fertilizer manufacturers in the south, west, and east, for the purpose of learning their views. The chief chemist of this Station was appointed chairman of the sub-committee for the east. This sub-committee met a committee of the Chemical Fertilizer Manufacturers' Association in Boston, in May, 1898, at which time a practically mutual agreement was effected as to what points in fertilizer laws should be made uniform in the several States.

A meeting of the joint committee was called to meet in Washington, D. C., on November 17th, at 2.30 P. M., for the purpose of hearing the reports of the sub-committees, and for further action. Adjourned meetings were held on succeeding days during the period in which the Association of Official Agricultural Chemists of the United States was in session, and finally a joint report was adopted which was endorsed on November 21st by the association just mentioned, and on November 24th, by the Association of American Agricultural Colleges and Experiment Stations.

The committees heretofore appointed by the two associations were continued as standing committees on fertilizer legislation.

METHODS OF ANALYSIS.

During the past year, work has been done on methods of determining the form of organic nitrogen in fertilizers, and also on soil and ash analysis in coöperation with the referees on these subjects, appointed by the Association of Official Agricultural Chemists. Mr. B. L. Hartwell, first assistant chemist of the Station, was appointed associate referee in October, 1897, and in connection with the referee, Prof. Harry Snyder of Minnesota, outlined the work of investigation on methods of soil and ash analysis.

Special work has been continued on methods of determining the relative acidity of soils, and further investigations have been made of the method of Müntz for determining the free "humus" of soils.

SPECIAL CHEMICAL INVESTIGATIONS.

So far as time has permitted, further progress has been made in the analysis of crops grown in certain of the pot and field experiments for the purpose of learning what has been the action of the various manurial substances employed. This work was seriously interrupted during the summer and early autumn, owing to additions which were made to the laboratory building, which necessitated the complete suspension of analytical work for some time, and which seriously interfered with it for an even longer period. It is to be regretted that sufficient means are not at disposal to enable more work in this line, as well as in special soil investigations, to be conducted at this Station, since these studies bear so directly upon the economical production of crops in Rhode Island.

FIELD EXPERIMENTS.

The field experiments under the immediate supervision of this division were largely augmented by the addition, in the spring of 1898, of those experiments which had formerly been in charge of ex-Director Flagg, thus placing the entire field experiments, aside

from those of Director Brigham on plant breeding, in the care of this division. A considerable number of coöperative experiments upon individual farms, in various portions of the State, have also been conducted for the purpose of still further ascertaining in how far a lack of lime is general in Rhode Island soils. These experiments are so promising of further usefulness that their continuance for a few years seems to be one of the imperative lines for the Station to pursue.

POT EXPERIMENTS.

In the spring of 1898 it became necessary to remove the ninety-eight 18x26 inch iron pots, which were set in the ground back of the chemical laboratory, to a new location. This was successfully accomplished, the pots having been entirely refilled and a new line of experimental work begun. Some of the soil formerly in these pots was, however, reserved for the purpose of further testing the after effect of the use of sulfur and of calcium chloride, which had been used in the former experiments on potato scab. Sixty-three of these pots were set aside for special investigations, and were manured alike, nitrogen, however, being omitted, for the purpose of testing the uniformity of the soil before commencing the experiment in 1899. The balance of the pots, and about two hundred others, which are kept on trucks and run into a glass house at night for protection, were employed in various experiments on the value of soda as a manure, on the cause for the occasional poisonous action of calcium, ammonium and magnesium chlorids, on the relative assimilability of phosphates of various kinds, on the influence of lime upon the assimilability of the phosphoric acid of soils, and in a plant soil test of a soil sent from another portion of the State.

EXPERIMENTS IN CULTURE UNDER GLASS.

This division has continued, in coöperation with the assistant horticulturist, the initiatory experiments upon the effect of physical

conditions and kinds of manures upon the growth of certain plants in greenhouse culture. The greenhouse is in a most dilapidated condition, and wholly unsuited for such work, yet it has been hoped that some preliminary data could be obtained which would serve a useful purpose as a basis for experiments in a better house, if such a structure is at any time provided.

LABORATORY FACILITIES.

During the year a muffle furnace has been added to the equipment. This had become an absolute necessity in view of the ash analyses which have to be made in connection with certain of the field and pot experiments before definite conclusions can be drawn as to the specific action of certain manures.

Owing to the reconstruction of the chemical laboratory building, the north wing, which had been recently vacated by the college as a chemical laboratory, and which was designed for use by this division, has been set aside for the use of the biologist, and another laboratory room over the present one has been assigned for the additional chemical work. This room has no fittings whatever, and should be equipped for use at the earliest opportunity. It is serving a useful purpose at present as a storage room for crops which are drying preparatory to analyses, for which proper space has been wholly lacking heretofore. Before this division is suitably equipped an electric motor, or other means of furnishing power, should be provided, and, also, suitable drying arrangements for handling large quantities of crops, and mills for use in sampling and grinding the same.

INSPECTION OF EUROPEAN EXPERIMENT STATIONS.

The chief chemist of the Station visited a number of the more prominent Agricultural Experiment Stations of Europe, in 1888 and 1889, among which were those at Darmstadt, Halle, Möckern, near Leipsic, Bernburg, and Göttingen, in Germany, and the private station of Sir John B. Lawes, in England. Owing to the contem-

plated changes in the chemical laboratory building, and to the consequent interference with certain of the lines of work of the division, a leave of absence was asked for, in June, 1898, to enable the chemist to again visit some of the leading stations of Europe, for the purpose of studying their work in the line of pot and field experiments, soils, manures, etc. For this purpose sixteen European stations were visited, including four in France, one in Belgium, one in Holland, the balance being in Germany. Incidentally visits were also made to a few coöperative creameries, large farms, two large fertilizer manufactories, the German Agricultural Society, and to a number of agricultural educational institutions of Germany, Holland, and Belgium. An attempt was made to obtain as good an idea as possible of the general practice of agriculture in Europe, of the condition of the fertilizer trade and its regulation, of the management of their great agricultural society, and of agricultural educational work in general, as well as as of the special experimental work which was made the chief object of the visit.

It was hoped that some information relative to the methods and lines of European investigation might thus be gathered which would render the work of this division of greater service to the cause of agriculture in Rhode Island.

CORRESPONDENCE AND PUBLICATIONS.

The work of correspondence has been practically as great as that in former years. More inquiries for special fertilizer formulas, and as to the desirability of using the various forms of individual manurial substances, like nitrate of soda, sulfate of ammonia, muriate and sulfate of potash for special crops, have come to hand than ever before. When the fertilizer inspection was transferred to the Station it was found that there were still many hundreds of dollars of outstanding fees which were already long overdue, and the correspondence involved in securing the payment of the same to the State Treasurer was considerable.

ACKNOWLEDGMENTS.

Once more it is a pleasant duty to acknowledge the efficient and cordial coöperation of those farmers upon whose land special experiments have been tried. It is always a hopeful sign and a source of much encouragement to find our farmers ready to assist the Station in this way, in gathering and disseminating information which will be useful to others.

In connection with the field experiments, the work of Mr. J. A. Tillinghast, in the way of counsel in relation to many practical matters, and in immediate supervision of all the details of the work, is worthy of the highest commendation in every particular.

The services of Mr. B. L. Hartwell, as first assistant chemist, have been, as heretofore, most efficient, and it is a source of much satisfaction that the Station has been able to retain him in spite of a favorable inducement to become a candidate for a more remunerative position in another State.

Mr. G. E. Adams has manifested great interest and executed to the fullest satisfaction such work as has been entrusted to his care.

In the care of the pot experiments my thanks are especially due to Mr. N. L. C. Moore, whose interest in, and knowledge of, the problems under investigation has rendered his services of unusual value.

MISCELLANEOUS ANALYSES.

Certain miscellaneous analyses, which in some instances have no connection with investigations in progress, and which in a few other instances it seems desirable to record separately, are given here.

Just before the close of the year 1897 a sample of cotton-seed meal was received from Mr. Benj. F. Smith, of Pawtucket, with the statement that it did not seem to be giving satisfaction as a cattle food, and with the request that the Station should make an analysis of it. In view of the fact that two of the New England

States had already found such flagrant adulterations of concentrated commercial feeding stuffs as to lead them to resort to legislative action for the protection of purchasers, it was deemed wise to examine, so far as time and circumstances permitted, such samples of feeding stuffs as might be sent here for examination.

321. Cotton-seed meal, sent by Benj. F. Smith, Pawtucket.
322. Cotton-seed meal from R. G. Palmer, Elmhurst.
323. " " " A. A. Smith, Woonsocket.
324. " " " T. P. Braman, West Kingston.
325. " " " Henry Aldrich, Woonsocket.
326. " " " " " "
327. " " " H. Howard, Abbott Run.

	321. Per cent.	322. Per cent.	323. Per cent.	324. Per cent.	325. Per cent.	326. Per cent.	327. Per cent.
Nitrogen	4.33	3.56	3.85	4.33	7.35	3.70	7.10
Crude protein (N. x 6.25)	27.06	22.25	24.06	27.06	45.94	23.13	44.38
Crude fat	5.81	*	*	*	*	*	*

Samples Nos. 325 and 327 represent cotton-seed meal of good quality, such as purchasers have reason to expect, yet, as will be seen from the above tests, five of the seven samples contain only about one-half as much protein as they should, and consequently are only about half as valuable as they should be, either for feeding or manurial purposes. Furthermore, the meal seemed in each case to be adulterated with cotton-seed hulls, and since the protein contained in them is much less digestible than that in good meal, the actual feeding value is even lower than that indicated by the chemical analysis. The amount of fat in sample No. 321 was also less than half as great as it should have been. The same was unquestionably true of the other samples, which were low in protein in which fat was not determined owing to the fact that the low percentage of nitrogen was sufficent evidence of adulteration.

* Not determined.

In view of the large trade in gluten meals and the fact that some of them are also only one-half as valuable as others may lead to the necessity of a concentrated feeding stuff law in this State similar to the one regulating the sale of commercial fertilizers. This would seem to be even more necessary than heretofore, since legislation is driving dealers in poor goods out of other States, and is naturally sending them to fields where they can carry on their traffic undisturbed.

It is a significant fact to note that consumers are already realizing the threatening danger, and are taking steps looking to their own protection in the future.

328, 329, and 330, refuse from indigo dye vats, from Henry L. Greene, Riverpoint.

	328.	329.	330.
	Per cent.	Per cent.	Per cent.
Loss in weight by drying at 100° C	12.93	18.78	30.80
Lime (calcium oxide)	29.28	43.72	39.54
Zinc oxide (ZnO)	12.16	10.42	6.34

This material has been given away to such farmers as desired to avail themselves of it. In view, however, of the large amount of zinc which it contains, it has been deemed advisable to test its effect upon the growth of plants. To this end some of the material like sample No. 328 was used in pots, at such a rate as to furnish for the area of the pot approximately the same amount of lime as would be supplied by a dressing of air-slacked lime at the rate of 1.6 tons per acre. In comparison with it a like quantity of lime was tried in the form of pure carbonate of lime.

When the refuse from the indigo dye vats was used lettuce absolutely refused to grow, and barley was decidedly injured, while by the employment of pure carbonate of lime both crops grew well. It will be seen from the above statement that unusual amounts of the waste lime were not used, since it was applied at a rate equivalent to but about 1.6 tons of air-slacked lime per acre, and applications of as high as from two, to two and one-half tons of air-slacked lime are not unusual. It is possible that less

injury would have resulted had the waste lime been used in the field, a point which it is hoped to determine later. For the present, however, one would not be justified in recommending the unlimited use of this material.

Sample No. 329 contained rather less zinc, and far more lime, and sample No. 330 contained but little more than half as much zinc, with a much greater amount of lime than sample No. 328. Had either of these samples been employed in the experiment, especially the latter, much less injury would probably have resulted. In the case of No. 330 a ton of the material, which would have been equivalent to about half a ton of air-slacked lime per acre, might have shown no appreciable injury, especially in connection with plants which are not naturally highly sensitive to injury by zinc compounds.

331. Belgian phosphate, used as a filler in commercial fertilizers for the purpose of making them drill better, and to prevent caking.

332. Floats, or finely ground phosphate rock, used at the Station.

	331.	332.
	Per cent.	Per cent.
Water	*	0.61
Phosphoric acid	7.78	28.09

333. Tankage, consisting largely of moist cooked meat in a coarse form, from T. S. Barnes, Lakewood.

334. Finely ground steamed bone, used by the Station.

335. Finely ground tankage, used by the Station.

	333.	334.	335.
	Per cent.	Per cent.	Per cent.
Water	*	6.19	5.84
Phosphoric acid	*	26.52	13.62
Nitrogen	4.90	2.44	5.36

336. Burned lime, sampled for Station purposes.

	336.
	Per cent.
Lime (calcium oxide)	59.23
Magnesia (magnesium oxid)	39.89

* Not determined.

337. Acid phosphate, used by the Station.
338. Double superphosphate, used by the Station.
339. Dissolved bone, used by the Station.
340. Dissolved boneblack, used by the Station.

	337.	338.	339.	340.
	Per cent.	Per cent.	Per cent.	Per cent.
Water	8.78	13.32	7.54	15.81
Soluble phosphoric acid	13.55	40.12	6.18	11.40
Reverted " "	4.18	2.78	7.22	5.74
Insoluble " "	0.72	2.57	2.80	1.70
Total " "	18.40	45.47	16.20	18.84
Nitrogen	......	.....	2.82	.....

341. Dried blood, used by the Station.
342. Nitrate of soda.
343. Sulfate of ammonia.

	341.	342.	343.
	Per cent.	Per cent.	Per cent.
Water	8.15	4.27	1.65
Nitrogen	9.97	15.30	20.86

344. Carbonate of soda, used by the Station.
345. Common salt, used by the Station.

	344.	345.
	Per cent.	Per cent.
Water	3.90	5.17
Soda (sodium oxide)	55.67	49.51

Sample No. 344 contained traces of potash and chlorine.

346. Carbonate of potash, used by the Station.
347. Nitrate of potash, " " "
348. Muriate of potash, " " "

	346.	347.	348.
	Per cent.	Per cent.	Per cent.
Water	13.90	2.13	0.53
Potash (potassium oxide)	57.94	44.35	51.54
Nitrogen	......	12.85	......
Chlorine	Traces.	1.70	......

Sample No. 346 also contained traces of sulfuric acid.

AGRICULTURAL DIVISION.

Upon the Possibility of Drawing Erroneous Conclusions from Plant Soil Tests designed as Guides to the Economical Manurial Treatment of Soils, and to Serve as a Basis for the Development of Reliable Chemical Methods for ascertaining their Requirements.

H. J. WHEELER AND J. A. TILLINGHAST.

Owing to the difficulty experienced in attempting to draw satisfactory conclusions as to the manurial requirements of soils long under cultivation by resort solely to chemical analysis, agricultural investigators have been led to recommend the employment of soil tests, with plants and fertilizers, as the surest means of ascertaining their needs. Undoubtedly many thousand tests of this character have already been made in this country and in Europe, and, when conducted with care, the information afforded by them has usually been looked upon as a practically infallible guide to the economical manuring of soils. In conducting soil tests the number of plots employed varies according to the amount of uniform land at disposal, and the individual views of the experimentor.

Frequently such tests are devoted solely to learning the relative lack of nitrogen, phosphoric acid, and potash. In this case the least number of plots permissible would be three, as follows: one with nitrogen and phosphoric acid, one with nitrogen and potash, and one with potash and phosphoric acid. A plot with a combi-

nation of all three substances, as well as one without manure, is desirable, and frequently included. Occasionally, also, three other plots, manured each with a single substance, are employed. The first object of this article is to show that in soils of a certain character and containing certain forms of plant food, the conclusions drawn from such a soil test upon unlimed land may not accord with the results obtained after liming. The experiment to be described was begun in 1890, and has been continued without interruption until the present time. The details of each year's results are to be found in the annual reports of this Station, from 1890 to 1897, inclusive. The experiment comprised an unmanured plot, three plots upon each of which single manurial substances were applied, three plots each with combinations of two of the manurial substances, and one with all three. The unmanured plot was contaminated at the outstart upon the northern end, and the two ends of the plot which received all three manures had formerly received unlike treatment. Chiefly on this account, but also to simplify and make clearer the data which it is necessary to present here, the yields upon these two plots have been left out of the discussion. It should be stated, however, that upon the uncontaminated end of the unmanured plot the yields have usually been much inferior to those where manures were applied, while a combination of all three manures has given, generally, somewhat greater returns than where a single manurial substance has been omitted, thus showing, prior to the present year, that all three manurial substances were, to a certain extent, deficient in the soil.

From 1890 to 1893, inclusive, the only crop grown upon the plots was Indian corn. In 1894 thirty-seven varieties of plants were grown, in rows running crosswise of the plots, with the hope of obtaining indications as to whether all of the plants would show similar soil deficiencies when emploved in such a test. Ten of the most dissimilar varieties tested in 1894 were again used in 1895, Indian corn having been omitted. The number of varieties was reduced in order that more rows of each kind might be grown and the reliability of the data thereby increased. In pursuance of the

same idea the number of plants was further reduced to six, in 1896, with the introduction of Indian corn to serve as a check upon the results.

In view of the fact that since the beginning of the experiment many soils in the State had been found to lack lime, it was deemed wise to ascertain how nearly identical the results of a soil test would be found before and after liming. Accordingly the plots were all limed uniformly in the spring of 1896, at the rate of two and one-half tons of air-slacked lime per acre.

In 1897 only five varieties of plants were grown, and the results proved of unusual interest, for the reason that Indian corn, which in previous years had shown its inability to make a fair growth, even when abundantly supplied with potash and nitrogen, appeared now, for some reason, to make an excellent growth under the same conditions, and to become largely independent of phosphatic manures. This was attributed to the excessive and well distributed rainfall, to the liming, or to a combination of both factors, though the lime seemed to be the most important agent in bringing about this change. In order to obtain further data, and to make the results as conclusive as possible, the entire areas of all of the plots were devoted to Indian corn in 1898.

The plots comprising the experiment contain each one-twentieth of an acre, and are separated from one another by paths three feet wide. The order of arrangement and the method of manuring were as follows:

Plot 1. No manure.
" 2. Nitrogen.
" 3. Potash.
" 4. Nitrogen and phosphoric acid.
" 5. Nitrogen and potash.
" 6. Potash and phosphoric acid.

Nitrogen was employed in every case as nitrate of soda, phos-

phoric acid as dissolved boneblack, and potash as muriate of potash.

To those plots where the manurial substances were applied, either singly or in connection with others, the annual rates per acre have been, for the various years, as indicated below:

	In 1890 and 1891. *Pounds per acre.*	In 1892 and subsequently. *Pounds per acre.*
Nitrate of soda	150	480
Dissolved boneblack	350	600
Muriate of potash	150	200

The amounts of the manurial substances were increased in 1892 in order that, if any one ingredient were lacking in the soil, the plants wherever it was applied would respond to the greatest possible extent, and thus show the real soil deficiencies in a more marked manner than previously.

The tillage upon all of the plots has been uniform from the outstart.

The results secured with Indian corn, from 1890 to 1898, are given in the subjoined table. Indian corn was not grown on the plots in 1895, but it was introduced again in 1896, chiefly to serve as a check in case unusual results were obtained with any of the crops recently employed in the experiment. The wisdom of this course has become manifest, for, had this not been done, one might have been led to believe that the differences observed before and after liming were due more to the peculiarities of certain varieties of plants than to the lime itself, and thus the actual facts might have escaped detection.

Table showing the Relative Weights (in Pounds) of Maize obtained in a Soil Test in the Years before and after Liming the Soil.

(In the year 1895 maize was not grown upon the plots.)

Plot No.	MANURES.	YIELDS BEFORE LIMING.					YIELDS AFTER LIMING.		
		1890.	1891.	1892.	1893.	1894.	1896.†	1897.	1898.
		Corn and Stover.	Corn and Stover.	Corn and Stover.	Corn and Stover.	Corn and Stover.*	Corn and Stover.	Corn Fodder.‡	Corn and Stover.
1.	Nitrogen	180.0	60.0	60.0	50.0	26.0	10.6	108.3	215.0
2.	Phosphoric acid	210.0	129.0	180.0	145.0	88.0	20.8	32.6	130.0
3.	Potash	293.8	107.5	61.0	112.5	28.0	11.9	183.8	295.0
4.	Nitrogen and phosphoric acid.	278.8	189.5	205.0	122.5	116.0	38.5	180.3	350.0
5.	Nitrogen and potash	282.5	112.5	88.0	102.5	32.0	26.8	222.5	395.0
6.	Potash and phosphoric acid.	293.8	157.8	230.0	163.8	202.0	49.2	230.8	335.0

From the foregoing table it will be seen that in 1890, potash used alone (plot 3) was more effective than phosphoric acid or nitrogen when similarly employed. Potash in connection with nitrogen, and with phosphoric acid, was also more effective than nitrogen and phosphoric acid applied together. In fact, the first season's results indicated that the soil lacked potash most of all, followed in turn by phosphoric acid and nitrogen. In the years from 1891 to 1894, inclusive, phosphoric acid applied alone was far more effective than either nitrogen or potash when used singly. It will also be seen that, without exception, where phosphoric acid was used in connection with either nitrogen or potash, greater

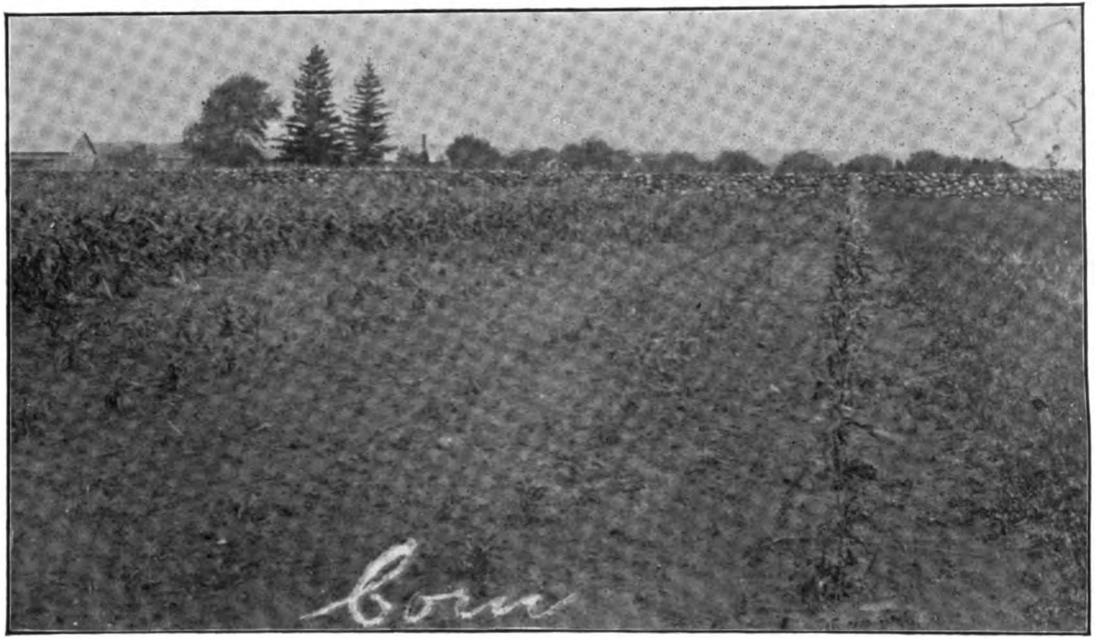
* Yield from two rows only, running crosswise of the plots.

† Limed in the spring of 1896 and planted immediately. Yield from eight rows only, running crosswise of the plots.

‡ Yield from eight rows only, running crosswise of the plots.

Plot 2. Phosphoric Acid.

Plot 1. Nitrogen.

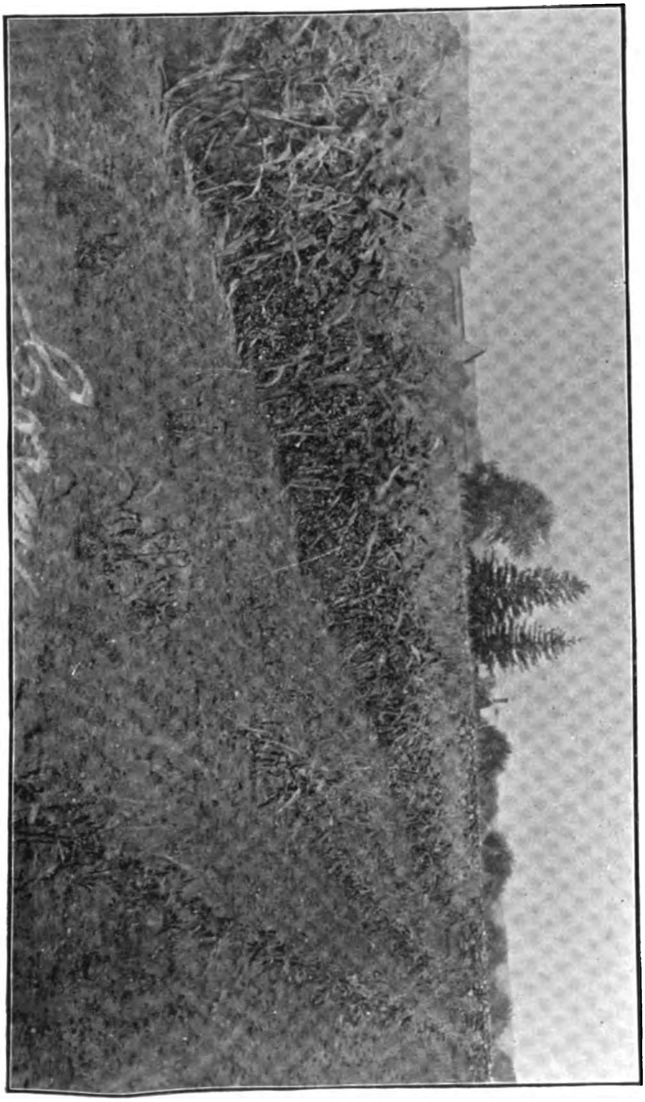


Plot 0. No manure.

FIG. 1.
Indian corn. *Soil test, 1893.*

Plot 4.

Phosphoric Acid and Nitrogen.

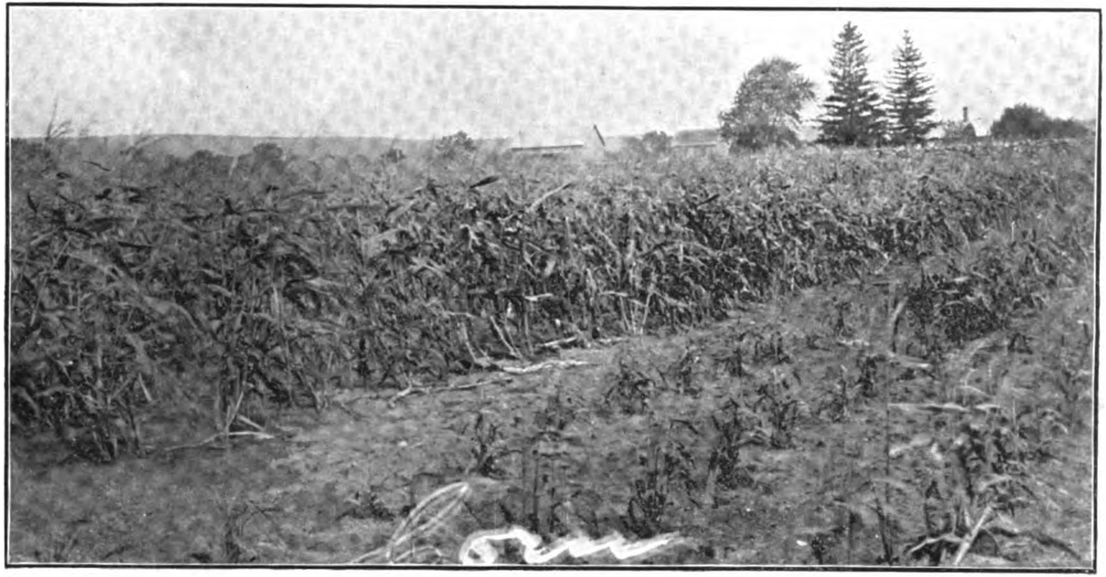


Plot 3. Potash.

FIG. 2.

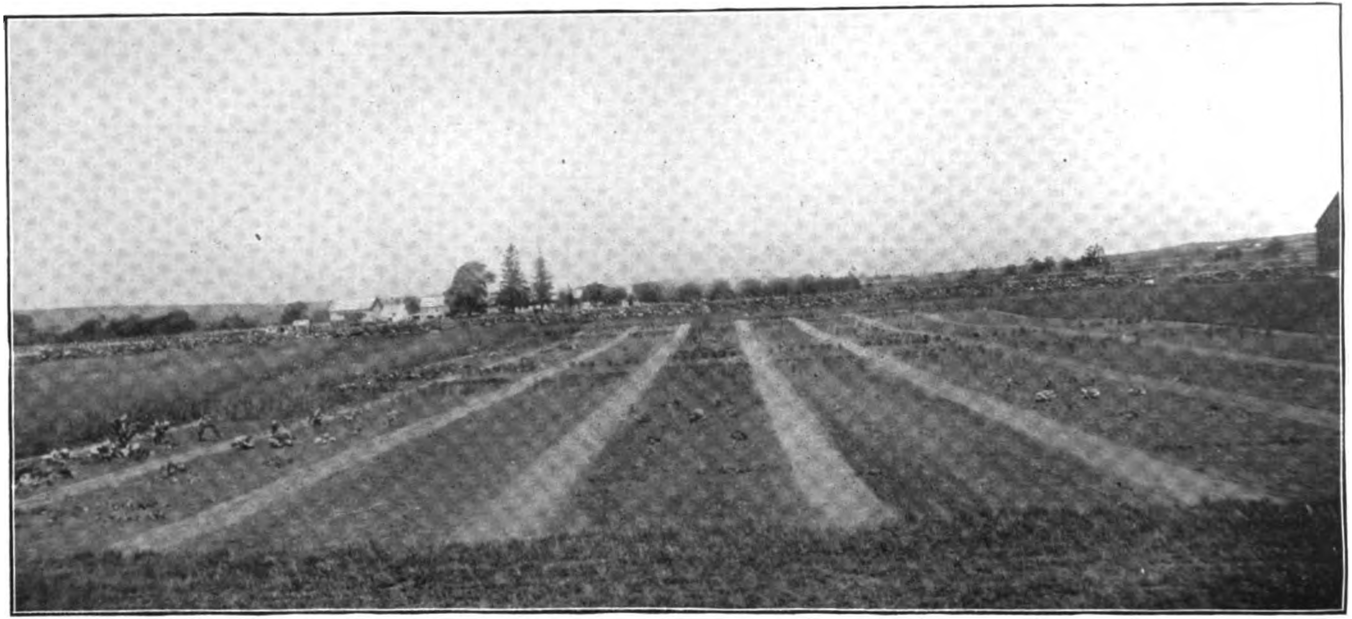
Indian corn. *Soil test, 1898.*

Plot 6.
Phosphoric Acid and Potash.



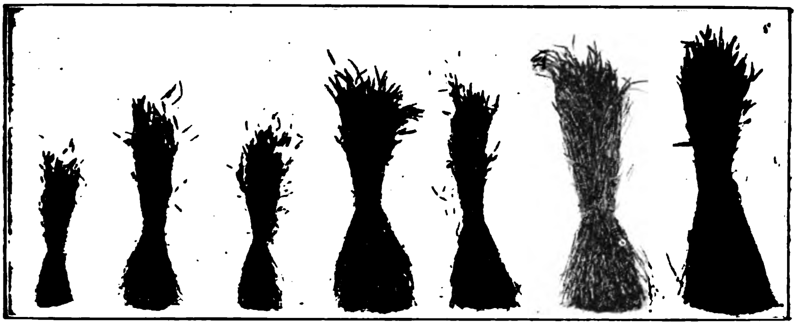
Plot 5. Potash and Nitrogen.

Fig. 8.
Indian corn. *Soil test*, 1893.



Plot 7.	Plot 6.	Plot 5.	Plot 4.	Plot 3.	Plot 2.	Plot 1.	Plot 0.
Phos. Acid, Potash and Nitrogen. Lime in foreground.	Phosphoric Acid and Potash.	Nitrogen.	Phosphoric Acid and Nitrogen.	Potash.	Phosphoric Acid.	Nitrogen.	No Manure.

Fig. 4.
Miscellaneous crops. *Soil test, 1894.*



N.* P.A. P. P.A. & N. N. & P. P. & P.A. N., P. & P.A.

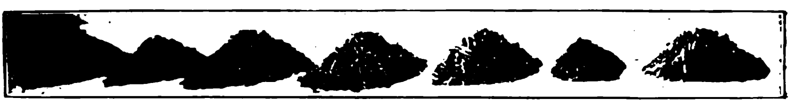
Fig. 5.

Rye. *Soil test*, 1896

N.* P.A. P. P.A. & N. N. & P. P. & P.A. N., P. & P A.

Fig. 6.

Millet. *Soil test*, 1896.



N., P. & P.A. P. & P.A. N. & P. P.A. & N. P. P A. N.*

Fig. 7.

Indian corn (ears). *Soil test*, 1898.

* Note.—N. = Nitrogen ; P.A. = Phosphoric acid ; and P. = Potash. In Fig. 7 the arrangement of the piles was the reverse of that in 1896. The marked deficiency of phosphoric acid before liming and the result after it had become thoroughly mixed with the soil are shown most strongly by comparing Figs. 1, 2 and 3 with Fig. 7.

yields were obtained than from potash in connection with nitrogen. In every instance, in each of the four years, phosphoric acid and nitrogen proved inferior to phosphoric acid and potash. From this it was concluded that the soil lacked chiefly phosphoric acid, followed in order by potash and nitrogen.

The first year's results indicated that the supply of directly assimilable phosphoric acid was nearly enough for that season, but that it was so far exhausted by one crop that it became the most deficient manure of all in the succeeding four years.

In 1895 Indian corn was omitted from the experiment in order to introduce as many as possible of the crops not heretofore sufficiently tested.*

In entering upon a discussion of the results for the last three years, it must be borne in mind that all of the plots received an application of air-slacked lime in the spring of 1896, at the rate of two and one-half tons per acre. From the foregoing table it is seen that in 1896 phosphoric acid used singly or in connection with one other manurial substance proved, as heretofore, more effective than either nitrogen or potash when similarly employed. In 1897 and 1898 the use of nitrogen or of potash alone proved *far superior* to phosphoric acid alone, results which stand in direct opposition to those in the six years which had preceded. Again, in 1897 the crop upon the potash and nitrogen plot (No. 5) was

*The results obtained showed that the plants had, on the whole, done as well upon the potash and nitrogen plot (No. 5) as upon that where phosphoric acid and nitrogen had been continuously used; in most cases, nevertheless, the crops on the phosphoric acid and potash plot were best of all. This latter circumstance, together with the great superiority of the crops where phosphoric acid was used alone, as compared with those from either nitrogen or potash when used singly, led to the supposition that in some way the manures intended for the phosphoric acid and nitrogen plot (No. 5) had been interchanged for those which should have been applied to the nitrogen and potash plot (No. 4). This view was still further strengthened by the fact that these exceptional results were in such strong contrast to those of the four years immediately preceding. Even if such an interchange took place, the quantities of manurial ingredients applied in a single year were presumably not great enough to produce any very lasting disturbance in the plots, and, in fact, in 1896 the yields upon the nitrogen and potash plot again dropped below those upon the one to which phosphoric acid and nitrogen were applied, showing that if an interchange had taken place in 1895, no marked disturbances were noticeable, in consequence thereof, the succeeding year.

much greater than where phosphoric acid and nitrogen were used (plot 4), though still slightly inferior to the results secured with phosphoric acid and potash (plot 6). In 1898 the plot receiving potash and nitrogen produced a greater crop than any other of the plots embraced in the experiment. Apparently, also, a large amount of assimilable phosphoric acid was at the disposal of the crop upon plots 1, 3, and 5, which in the earlier years of the experiment frequently showed a most striking deficiency in this particular.

It is impossible to explain these data upon the hypothesis that the results on plot 5 (the nitrogen and potash plot) were caused by an after effect of phosphoric acid, which may have been applied to this plot by accident in 1895, as suggested in the preceding foot note, for in this way one cannot account for the wonderful transformation which has resulted so far as concerns the crops produced in 1897 and 1898 upon the plots where nitrogen and potash were applied singly (plots 1 and 3). The low yield in 1896 upon the plot receiving potash and nitrogen is a further argument against such an explanation. One seems, therefore, to be forced to the conclusion that an unusual amount of assimilable phosphoric acid had become available to the plants from the abundant, though comparatively useless, stores of that ingredient heretofore locked up in forms which could not be utilized.

That such a liberation of phosphoric acid may have been due in part to the frequent rain-falls of 1897 and 1898 seems probable, yet the chief agent in effecting the change which appears to have resulted in the assimilability of the phosphoric acid stored up in the soil seems to have been the lime; though indirectly the unusual amount of moisture in the soil doubtless played an important part in rendering the lime more effective than would otherwise have been the case. It is not surprising, even if the results noted are attributable chiefly to the lime, that it remained, apparently, ineffective the first season. This must be obvious when one considers how impossible it is to mix lime thoroughly with the soil at once. Doubtless, also, the comparatively small amount of water

in the soil, as compared with that in the spring and fall, as well as the short period intervening in which the lime could react upon the phosphates of the soil, were important reasons why the lime did not have a marked effect upon the result of the test in 1896.

Hilgard,* in speaking of the phosphoric acid in soils, says: "Anything much above one-tenth of one per cent. usually proves, in virgin soils, to be quite a full supply, rendering the use of phosphates ineffective for a number of years." It is of interest to note how the conclusions applying to virgin soils compare with those drawn from the chemical analysis of the soil employed in this test.† In the autumn of 1894 samples of the soil from the plot where phosphoric acid was used alone (plot 2), and from that where potash and nitrogen had been employed (plot 5) were collected and forwarded to the reporters on soils of the Association of Official Agricultural Chemists, for use in the investigations of methods of soil analysis. These samples were selected for the purpose because the soil had been found by previous tests with plants to stand greatly in need of phosphoric acid. The average of seven determinations by digestion for ten hours, with hydrochloric acid of 1.115 specific gravity showed the phosphoric acid to amount, in the case of the plot where phosphoric acid only had been applied (plot 2), to .202 per cent.; and in the case of the plot where nitrogen and potash had been used, to .191 per cent. The average results obtained by digesting one hour with concentrated sulfuric acid, in some cases without and in others with the aid of nitric acid, were .262 and .251 per cent., respectively. The percentages obtained by hydrochloric acid were the result of ten hours digestion, while Hilgard's method calls for the continuance of the digestion for five days. Had the Hilgard method been strictly followed, therefore, the percentages of phosphoric acid found would probably have been greater rather than less, so that at all events the soils contained more than double the amount of phosphoric acid which in virgin soil should usually, according to

* Jour. Am. Chem. Soc., 16 (1894) p. 46.

† It should be remarked that this soil is not what Hilgard calls a *virgin* soil.

Hilgard, insure the profitable production of crops for many years without resort to phosphatic manures. Incidentally it is of interest to note that notwithstanding the fact that the total amount of dissolved boneblack previously applied to plot 2 was equal to 2,500 pounds per acre, representing about 450 pounds of phosphoric acid, yet the difference in the amounts of phosphoric acid found in the soil upon the two plots, as shown by both methods of analysis, was but .011 of a per cent.

It must be evident from what has preceded that the soil in question, even to a depth of but a few inches, contains per acre vast amounts of phosphoric acid. If only a limited amount of this practically unassimilable material can be placed at the disposal of plants merely by liming, the results cannot fail to be of great practical value, since the annual applications of phosphoric acid might then be largely reduced, and the cost of the lime would be but slight as compared with the advantage gained. Adding to this the value of the lime in correcting the acidity and physical condition of our soils, whereby they can be made to produce greater yields of grass, clover, beets, and many other crops than before, it would appear that the question of liming may prove of even more importance than could have been anticipated.

It is hoped to experiment further with the purpose of learning if the condition is more or less general, and if there are other soils in the State containing large quantities of phosphoric acid which can be rendered of use to crops by resort to liming.

These results show that in studying methods of chemical analysis, additional care should be taken in conducting the tests by which one concludes as to whether phosphoric acid is deficient or not. For such purposes a soil could not legitimately be considered as seriously deficient in phosphoric acid which, after liming, would be capable of producing good crops for a series of years with but a slight outlay for phosphatic manures.

It remains to further study at the Station the duration of the liberation of phosphoric acid, and to see in how far it may be affected by variations in the rain-fall of different seasons.

SUMMARY.

The results obtained during the nine years since the soil test was begun have indicated:

1. That before liming, phosphoric acid was more needed than nitrogen or potash. (See Figs. 1, 2, 3 and 4.)

2. That after liming, the soil stood less in need of phosphoric acid than of potash or nitrogen. (See Fig. 7.)

3. That large quantities of phosphoric acid which had heretofore been largely unassimilable were made of use to plants by treating the soil with lime.*

4. That the above points should be taken into account, and lime applied to all the plots of a soil test, when experimenting with such soils as are acid, or in other respects stand in need of liming.

5. That in attempting to secure chemical methods for showing the manurial requirements of soils, as based upon soil tests with plants, erroneous conclusions may be drawn as to their relative reliability, if the other ingredients of which the soil stands in need are not applied to all of the plots before the tests as to the relative deficiency of potash, phosphoric acid, and nitrogen are begun.

* Dehérain (Traité de Chemie Agricole Paris, 1892, p. 421, also p. 524) calls attention to the fact, demonstrated by P. Thenard, viz.: that carbonate of lime in the presence of carbonated water acts upon insoluble sesquiphosphate of iron in such a manner as to render some of the phosphoric acid soluble. Carbonate of potash also exerts upon it a similar solvent action. He further cites an experience of Prof. Millot of the agricultural school at Grignon. The soil of a farm at Mondoubleau (Loir-et-Cher), belonging to Mr. Boitel, Inspector-General of Agriculture, was benefited in a high degree by the employment of phosphates. Their action was so temporary, however, that after a year the application had to be repeated. Millot, having noticed that the soil was exceptionally rich in oxid of iron, recommended the use of marl (impure carbonate of lime). The result was practically equivalent to what would have been obtained by a new application of phosphate. Large applications of lime are more efficacious for this purpose than small ones.

Whether lime in our case has liberated phosphoric acid from iron compounds, or from humous or other combinations, remains to be determined.

6. That one plant may not necessarily answer the question satisfactorily as to the manurial requirements of all other plants upon the same soil.

7. That, at least before liming, maize answers the question satisfactorily as to deficiencies of phosphoric acid, not only for the other cereals, but also for millet, beets, and many other crops.

8. That soil tests, designed to show what manurial substances will be yielded to plants in the least quantity for a series of years, must be continued for several seasons before final conclusions can safely be drawn.

On the Effectiveness of Nitrate of Potash, as compared with like amounts of Nitrogen and Potash in form of Muriate of Potash and Nitrate of Soda.

H. J. WHEELER AND J. A. TILLINGHAST.

This experiment was begun in 1895, and full details of the results, from year to year, may be found in the annual reports* of the Station.

Six plots are devoted to the experiment. Each plot is divided into two equal sections, each being cropped in a different way, though manured alike. In 1895 two of the plots (1 and 2) were limed at the rate of 5,000 pounds of air-slacked lime per acre. Two others (3 and 4) were given, per plot, an application of gypsum (land plaster) sufficiently great to furnish an amount of lime (calcium oxid) equal to that applied in the case of plots Nos. 1 and 2 in the form of air-slacked lime. The two remaining plots have received no lime in any form. No further application of air-slacked lime, or gypsum, has been made to any of the plots since the year 1895. The manuring has been generous each season, each plot receiving *like amounts* of phosphoric acid, potash, nitrogen, and magnesia.

The following are the amounts of manurial ingredients applied per plot in 1898:

Applied to each plot...........	13.3	pounds	dissolved boneblack.
	6.7	"	sulfate of magnesia (Epsom salts).
Applied to plots 2, 4 and 6. ...	6.7	"	muriate of potash.
	9.1	"	nitrate of soda.
Applied to plots 1, 3 and 5.......	7.8	"	nitrate of potash.

* Eighth An. Rpt. R. I. Ag'l Expt. Sta. (1895), pp. 226-231; Ninth An. Rpt. R. I. Ag'l Expt. Sta. (1896), pp. 237-240; Tenth An. Rpt. R. I. Ag'l Expt. Sta. (1897), pp. 236-239.

In 1898 one section of each plot was in grass, and the other was devoted to mangel-wurzels. The manures for the grass sections were applied April 26, and for the beet sections on June 6.

The first year of the experiment one-half of each plot was occupied by red table beets, and the other half by sugar beets. In the case of the sugar beets a greater yield was obtained on the limed plots from nitrate of soda and muriate of potash than from the nitrate of potash, but upon the unlimed plots, and those treated with gypsum, the reverse was true. With red table beets the nitrate of potash proved inferior only upon the gypsum plots. In 1896 barley and clover were grown. With barley the yield was less upon the unlimed plot where nitrate of potash was used than upon the unlimed one where nitrate of soda and muriate of potash were applied. Upon the gypsum and air-slacked lime plots the reverse was true. In every instance the crop of clover was greater upon the plots receiving muriate of potash together with nitrate of soda than upon those where nitrate of potash was used. It was not felt that much dependence could be placed upon the data from the clover sections, for the reason that some seed may have been blown from the plots during the prevalence of an unusually high wind soon after seeding. Owing to the drier condition of the surface of the air-slacked lime plots they probably suffered most in this particular. In 1897 the yields upon the gypsum plots were about equal, while in the case of the limed and unlimed plots, the nitrate of potash plots gave greater returns than the ones treated with nitrate of soda and muriate of potash.

The sections occupied by barley in 1896 were sown to timothy in 1897, the crop upon the air-slacked lime plots proving better where nitrate of potash was used than on the plot where nitrogen and potash were supplied in the other forms. Upon the gypsum and unlimed plot the reverse was true.

The grass crop of 1898 was cut on July 8, and again on July 31. The beets were harvested on September 27. The following table shows the yields of grass and beets obtained.

Table Showing the Results Secured with Nitrate of Potash in Comparison with like Quantities of Nitrogen and Potash in the form of Nitrate of Soda and Muriate of Potash.

(The weights given below represent pounds per section, *i. e.*, half a plot.)

NAME OF CROP.	AIR-SLACKED LIME IN 1895.		GYPSUM (LAND PLASTER) IN 1895.		WITHOUT LIME.	
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	Nitrate of potash.	Nitrate of soda and muriate of soda.	Nitrate of potash.	Nitrate of soda and muriate of potash.	Nitrate of potash.	Nitrate of soda and muriate of potash.
Grass (first crop, weighed green)............	133.1	145.7	123.2	176.2	136.0	169.1
Grass (second crop, weighed green).........	9.5	9.5	8.5	12.0	5.0	11.8
Total weight of grass....................	142.6	155.2	131.7	188.2	141.0	180.9
Mangel-wurzels (roots)......................	166.0	273.8	75.0	100.0	81.0	39.3

Samples of grass were taken in a uniform manner from each section and assorted in order to ascertain the relative percentages of timothy and redtop, for, though only timothy was sown, redtop had already usurped its place on some of the plots to a considerable extent. The following are the relative percentages thus obtained:

Air-Slacked Lime Plot.

Sections.	Per cent. Timothy.	Per cent. Redtop.
1. Nitrate of potash section.............................	92.3	7.7
2. Nitrate of soda and muriate of potash section..........	84.3	15.7

Gypsum (Land Plaster) Plot.

3. Nitrate of potash section.............................	72.7	27.3
4. Nitrate of soda and muriate of potash section..........	18.0	82.0

Unlimed Section.

5. Nitrate of potash section.............................	71.4	28.6
6. Nitrate of soda and muriate of potash section..........	75.3	24.7

Aside from the unlimed plots, the greatest per cent. of timothy was found upon those sections which received their nitrogen in the form of nitrate of potash. Upon the gypsum plots it will be seen that the grass upon the nitrate of potash section was about 73 per cent. timothy, while where nitrogen and potash were furnished in form of nitrate of soda and muriate of potash, the timothy amounted to but 18 per cent.

The most interesting feature of this experiment, in 1898, is that in every case, both with grass and mangel-wurzels, a greater total yield was obtained where nitrate of soda and muriate of potash were employed than in connection with like amounts of potash and nitrogen in form of nitrate of potash.

In view of the perfect harmony, in this particular, of all the results, it seems probable that some special value must be ascribed to the soda or chlorin, or, possibly, to both.

It was noticed, at the time the second crop of grass was cut, that the soil of the nitrate of potash section seemed to contain less moisture than that where nitrate of soda and muriate of potash had been applied. Preparations were made for taking samples of the soil for moisture determinations, but rain intervened before it could be done. Another season it is hoped to make such determinations frequently, for the purpose of ascertaining how great the influence of the manuring may be upon the water content of the soil.

It is not improbable, particularly in connection with the beets, that the soda may have been of some direct or indirect manurial value. The chlorin may also have exerted some manurial action, as already shown by Pfeiffer* in experiments with potatoes.

A continuation of this experiment for a few years more ought to furnish some positive information as to the worthlessness or possible value of the soda and chlorin of nitrate of soda and muriate of potash, which have, heretofore, been quite generally looked upon as ingredients of little or no agricultural value.

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* Die landw. Versuchs-Stationen 49, pp. 349–385.

THE FIFTH YEAR'S OBSERVATIONS ON THE SUBSTITUTION OF SODA FOR AND ITS VALUE IN CONNECTION WITH POTASH.

H. J. WHEELER AND J. A. TILLINGHAST.

This experiment was begun in 1894, and the results heretofore obtained are described in detail elsewhere.* Like quantities of nitrogen in form of dried blood, and of various forms of phosphoric acid have been applied annually to each plot. Since the first year sulfate of magnesia (Epsom salts) has also been applied. In the limed series the plots were treated with air-slacked lime, in 1894, at the rate of two tons per acre, and again, in 1896, at the rate of 1,200 pounds per acre. No lime has since been applied.

On account of the varying influence of the acid or alkaline reaction of soils upon the growth of certain plants, such quantities of sodium and potassium carbonate were employed in comparative tests as would neutralize like quantities of acid, rather than to employ like weights of the respective salts. The quantities of sodium chlorid (common salt) and of muriate of potash employed per plot, were such as to furnish the same equivalent of sodium and potassium, respectively, as the corresponding carbonates.

In 1898 the materials applied to each plot were used at the following rates:

	Rate per plot. *Pounds.*	Rate per acre *Pounds.*
Dried blood	17	1,020
Dissolved boneblack	10	600
Floats (finely ground phos. rock)	8	480
Magnesium sulfate (Epsom salts)	7	420

*Seventh Annual Report R. I. Agricultural Experiment Station (1894), pp. 168-182; Eighth Annual Report (1895), pp. 215-231; Ninth Annual Report (1896), pp. 221-241, and Tenth Annual Report (1898). pp. 226 240.

The full rations of the respective potassium and sodium salts were as follows:

	Ration per plot.	Ration per acre.
	Pounds.	*Pounds.*
Potassium carbonate	6.00	360.0
Sodium carbonate (soda ash).................... .. .	4.13	247.8
Muriate of potash (80 per cent. muriate)....	6.75	405.0
Sodium chlorid (common salt)......	4.64	278.4

The materials above enumerated were spread upon the surface, after plowing and harrowing, and thoroughly cultivated in. Oats were sown as early in the spring as possible. These were harvested on July 18, and the land was immediately plowed and sown to millet, which was harvested September 22 in a mature condition.

The much darker appearance of the borders of the plots during the growth of the second crop gave reason to suspect that, notwithstanding the heavy application of dried blood, the other plants were not obtaining sufficient nitrogen to enable them to make the fullest possible growth. In the case of plots 46 and 47, the oats remained light colored for some time in the spring after those on the other plots had begun to grow vigorously; later they gradually recovered. This retardation of growth was supposed to be due to delayed nitrification, though no logical reason for such an exception in the case of these two plots has suggested itself.

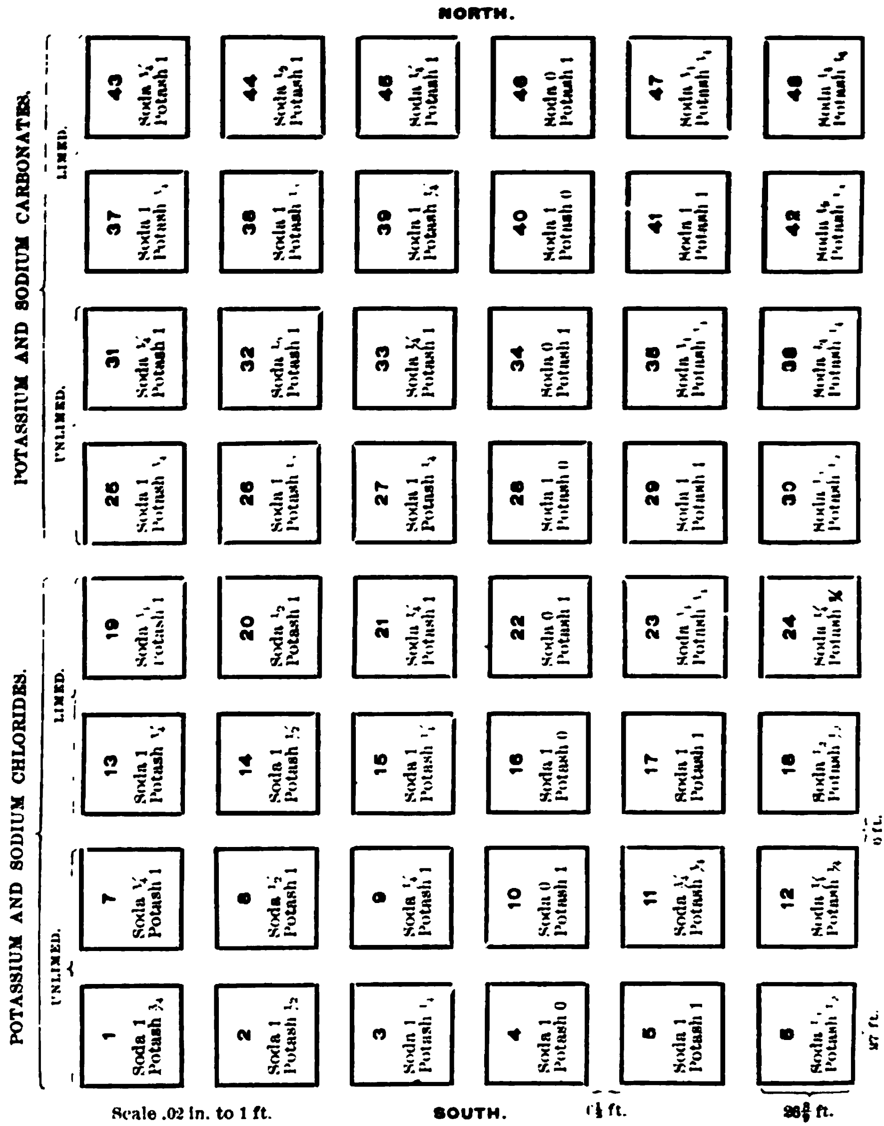
Among the plants selected for this experiment, during the first two years, were such as seemed most likely to be benefited by soda, and, on the other hand, certain ones having, presumably, little or no tendency in that direction. Having obtained photographs and weights of the products, the next step taken was to exhaust the natural supply of potash as rapidly as possible. To effect this two crops, oats and millet, have been grown in each of the succeeding years.

It was not until the second crop of 1896 that the signs of exhaustion began to be marked, and it was but slightly noticeable in the case of the first crop in 1897. The second crop of 1897 indicated the lack of potash in a striking degree, as have also the

first and second crops of 1898. It is now planned to test, in 1899, some of the plants of apparently widely varying tendencies which were employed in the experiment at the outstart.

The two following diagrams show the relative positions of the plots; the first indicates upon which plots one-fourth, one-half, three-fourths, and full rations of the respective sodium and potassium salts were used. Both diagrams show which sections have been devoted to carbonates, and which to chlorids of sodium and potassium, as well as those which have been limed. The second diagram shows the weights of undried fodder (oats and millet) upon each plot. The abbreviation "O" is used to indicate "oats," and "M" to indicate "millet." The oats employed were "Pringle's Progress," and the millet was that known as "golden millet." (See illustrations, Figs. 1 to 17.)

PLAN SHOWING THE ARRANGEMENT OF THE PLOTS AND THE KINDS OF FERTILIZING MATERIAL APPLIED TO EACH.



PLAN OF PLOTS CORRESPONDING TO THAT ON PAGE 140, SHOWING THE POUNDS OF OAT AND MILLET FODDER (WEIGHED GREEN) PER PLOT.

[*In the diagram O—oats and M—millet.*]

POTASSIUM AND SODIUM CHLORIDS.				POTASSIUM AND SODIUM CARBONATES.			
UNLIMED.		LIMED.		UNLIMED.		LIMED.	
1 O...274.0 M...184.1	**7** O...268.0 M...129.0	**13** O...314.0 M...186.9	**19** O...314.0 M...202.0	**25** O...284.0 M...196.8	**31** O...305.5 M...166.9	**37*** O...324.0 M...211.5	**43*** O...309.0 M...227.1
2 O...284.0 M...161.6	**8** O...299.0 M...162.2	**14** O...359.0 M...184.7	**20** O...369.0 M...213.3	**26** O...369.0 M...151.8	**32** O...339.0 M...176.7	**38** O...359.0 M...187.0	**44** O...354.0 M...199.6
3 O...259.0 M...131.8	**9** O...289.0 M...152.0	**15** O...361.5 M...122.1	**21** O...371.5 M...179.4	**27** O...304.0 M...101.8	**33** O...389.0 M...174.5	**39** O...369.0 M...154.6	**45** O...349.0 M...227.3
4 O...224.0 M... 81.4	**10** O...299.0 M...157.0	**16** O...159.0 M... 49.0	**22** O...354.0 M...107.0	**28** O...183.0 M... 57.1	**34** O...344.0 M...174.5	**40** O...254.0 M... 79.6	**46†** O...219.0 M...202.1
5 O...299.0 M...276.8	**11** O...304.0 M...146.9	**17** O...368.0 M...181.8	**23** O...359.0 M...177.0	**29** O...329.0 M...222.0	**35** O...331.0 M...226.8	**41** O...319.0 M...197.3	**47†** O...244.0 M...192.1
6 O...274.0 M...156.8	**12** O...279.0 M...131.6	**18** O...344.0 M...102.3	**24** O...334.0 M...121.9	**30** O...311.5 M...146.9	**36** O...294.0 M...131.8	**42** O...364.0 M...174.5	**48** O...314.0 M...142.1

* Injured somewhat, early in the season by standing water.

† The plants were slow in taking on a vigorous appearance, the nitrogen apparently not becoming rapidly assimilable, though without visible reason.

From the preceding record of yields it will be seen that in the case of the oats, a far greater crop was obtained in three out of four instances from the plots receiving potash without soda than from the ones receiving soda without potash. In the single instance where a contrary result was obtained, the oats upon the potash plot looked yellow for a long time. This seemed probably due to the fact that, for some unaccountable reason, the nitrogen of the dried blood was but slowly transformed into nitrates, in consequence of which the plants suffered from nitrogen hunger. When they finally began to take on a green appearance it was too late for them to wholly recuperate and to make a normal growth.

In the case of the millet, the yields from the plots receiving potash without soda were in all four instances far greater than where soda was applied without potash.

These results show the decided inferiority of soda as compared with potash, and are in full accord, in this respect, with the data secured in the years 1896 and 1897.

Comparing the yields from the plots which received a constant ration of potash, plus increasing amounts of soda, with the yields on those which received a constant ration of soda supplemented by increasing quantities of potash, it will be observed that the addition of soda to a constant full ration of potash was of no apparent benefit either to the first or second crop. On the contrary, where potash was added to a constant full ration of soda, marked gains are noticeable in the case of both crops. It will be seen that in 1898 the addition of a fourth ration of potash to the full ration of soda was practically as efficient as additions of half and three-quarter rations, which was not the case the previous year.

By an inspection of the yields upon the plots where a quarter ration of potash was used in connection with a quarter ration of soda, it will be observed that, as a whole, they approach closely those where a fourth ration of potash was used in connection with a full ration of soda. Again, the use of a half ration each of potash and soda was nearly as effective as a half ration of potash with a full ration of soda. A similar limited, and perhaps ques-

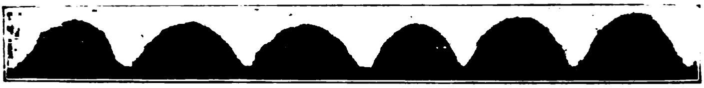


Fig. 1. Oats.

Potassium and Sodium Chlorids. *Unlimed.*

Potash ration.	1	1	1	1	¾	¼
Soda ration.	¾	⅛	¼	0	¾	¼

Fig. 2. Oats.

Potassium and Sodium Chlorids. *Unlimed.*

Potash ration.	¾	⅛	¼	0	1	½
Soda ration.	1	1	1	1	1	⅛

Fig. 3. Oats.

Potassium and Sodium Chlorids. *Limed.*

Potash ration.	1	1	1	1	¾	¼
Soda ration.	¾	⅛	¼	0	¾	¼

Fig. 4. Oats.

Potassium and Sodium Chlorids. *Limed.*

Potash ration.	¾	⅛	¼	0	1	½
Soda ration.	1	1	1	1	1	⅛

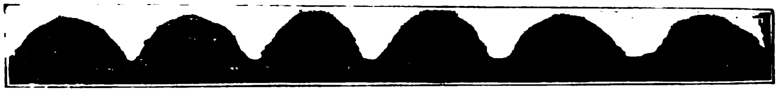


Fig. 5. Oats.

Potassium and Sodium Carbonates. *Unlimed.*

Potash ration.					
1	1	1	1	¾	¼
Soda ration.					
¾	½	¼	0	¾	¼

Fig. 6. Oats.

Potassium and Sodium Carbonates. *Unlimed.*

Potash ration.					
¾	½	¼	0	1	½
Soda ration.					
1	1	1	1	1	½

Fig. 7. Oats.

Potassium and Sodium Carbonates. *Limed.*

Potash ration.					
1	1	1	1	¾	¼
Soda ration.					
¾	½	¼	0	¾	¼

Fig. 8. Oats.

Potassium and Sodium Carbonates. *Limed.*

Potash ration.					
¾	½	¼	0	1	½
Soda ration.					
1	1	1	1	1	½

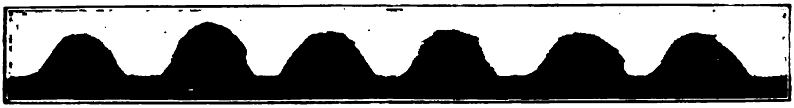


Fig. 9. Millet.

Potassium and Sodium Chlorids. *Unlimed.*

Potash ration. 1	1	1	1	¾	¼
Soda ration. ¾	½	¼	0	¾	¼

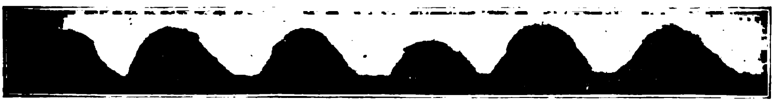


Fig. 10. Millet.

Potassium and Sodium Chlorids. *Unlimed.*

Potash ration. ¾	½	¼	0	1	½
Soda ration. 1	1	1	1	1	½

Fig. 11. Millet.

Potassium and Sodium Chlorids. *Limed.*

Potash ration. 1	1	1	1	¾	¼
Soda ration. ¾	½	¼	0	¾	¼

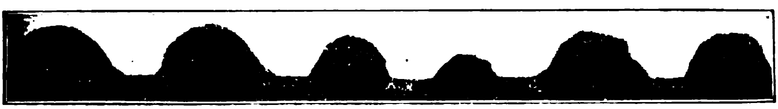


Fig. 12. Millet.

Potassium and Sodium Chlorids. *Limed.*

Potash ration. ¾	½	¼	0	1	½
Soda ration. 1	1	1	1	1	½

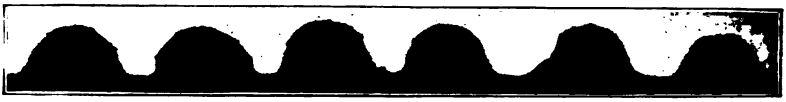


FIG. 13. MILLET.

Potassium and Sodium Carbonates. *Unlimed.*

Potash ration.	1	1	1	1	¾	¼
Soda ration.	¾	½	¼	0	¾	¼

FIG. 14. MILLET.

Potassium and Sodium Carbonates. *Unlimed.*

Potash ration.	¾	½	¼	0	1	½
Soda ration.	1	1	1	1	1	½

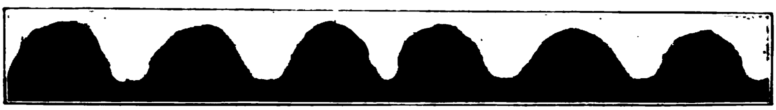


FIG. 15. MILLET.

Potassium and Sodium Carbonates. *Limed.*

Potash ration.	1	1	1	1	¾	¼
Soda ration.	¾	½	¼	0	¾	¼

FIG. 16. MILLET.

Potassium and Sodium Carbonates. *Limed.*

Potash ration.	¾	½	¼	0	1	½
Soda ration.	1	1	1	1	1	½

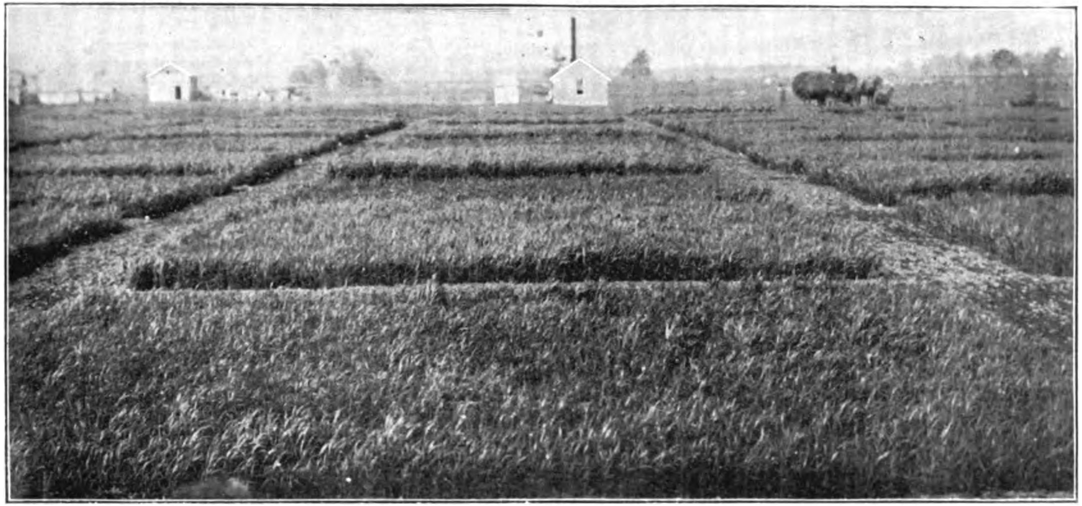


FIG. 17. MILLET.

Looking at the central row of plots one notices first a low crop, and next a higher one, and so on regularly from front to rear. The low crops are on the plots receiving soda but no potash, and the high ones on those receiving potash but no soda.

tionable, benefit from the extra amount of soda is seen when one compares the results from a three-quarters ration each of potash and soda with those from a three-quarters ration of potash in connection with a full ration of soda.

In 1897, particularly in the case of the second crop, where the supply of potash was reduced to half and three-quarters rations, the additions of soda proved much more effective. Though some possible explanations for that particular difference in the results of the two years suggest themselves, it does not seem desirable to discuss them until the data can be compared with the experience of future years.

SUMMARY. (*See Figs. 1 to 17.*)

The results for the year 1898 show the marked inferiority of soda when used without potash as compared with potash when used without soda, corroborating fully in this respect, the experience of previous years. When the potash supply was reduced to a quarter ration the soda proved quite effective.

Where the potash supply was equivalent to half and three-quarters rations the soda seemed to be far less effective than in 1897. It is hoped to determine later, by chemical analyses of the crops, whether the soda was probably serviceable directly as a plant food, or by virtue of its having rendered more assimilable some of the potash stored within the soil.

The practical question which it is hoped that this experiment may help to settle is whether it is or is not an economical practice to attempt to force plants to use soda by limiting their supply of potash. In this connection it is proposed to test both plants that do and those that do not seem likely to be helped by soda.

THE SIXTH YEAR'S OBSERVATIONS UPON THE GROWTH OF PLANTS UPON AN ACID UPLAND SOIL, LIMED AND UNLIMED.

H. J. WHEELER AND J. A. TILLINGHAST.

In the course of the six years since this experiment was begun about one hundred and twenty varieties of plants have been tested, in order to ascertain the effect of lime upon their growth. The details of these experiments are to be found in the former reports* of this Station. The trials have been made continuously upon the permanent experimental plots, Nos. 23, 25, 27, and 29. Like quantities of potash and phosphoric acid have been applied annually to each plot in the form of muriate of potash and dissolved boneblack. Like quantities of nitrogen have also been applied to each plot; that on plots 23 and 25 having been in the form of sulfate of ammonia, and that on plots 27 and 29 in the form of nitrate of soda. In 1897 and 1898 the quantities of nitrogen applied were but one-third as great as in former years, chiefly on account of the fruit trees, which it was thought would even then be provided with an ample supply. The actual quantities of sulfate of ammonia and nitrate of soda used per acre in 1897 were 87.6 and 116.25 pounds, respectively, while in 1898 they were 85.5 and 116.25 pounds. The actual amounts used were varied in accordance with the difference in chemical composition, in order to maintain constant the amount of *nitrogen* applied to each plot.

The amounts of muriate of potash and dissolved boneblack used were the same in 1898 as in 1897, viz., 300 pounds of the former, and 800 pounds of the latter.

Beginning with the year 1895, sulfate of magnesia (Epsom

* Sixth An. Rpt. (1893), pp. 224-252; Seventh An. Rpt. (1894), pp. 152-167; Eighth An. Rpt. (1895), pp. 205-214; Ninth An. Rpt. (1896), pp. 242-272, and Tenth An. Rpt. (1897), pp 202-225.

salts) has been applied equally to each plot up to the present time. The amount in 1895 was equivalent to 200 pounds, and in each subsequent year to 400 pounds per acre.

In 1893 plots 25 and 29 were limed at the rate of 5,400 pounds of air-slacked lime per acre, and again in 1894 at the rate of 1,000 pounds per acre, since which time no further applications have been made.

In 1898 the area which had been devoted to trials of miscellaneous grasses was employed for testing a number of crops not heretofore introduced into the experiment, or in regard to which still further data were deemed especially desirable.

A few of the small fruits, trees, vines, etc., were found in the spring of 1898 to have died, and were consequently reset; careful records of the same having been made.

The detailed observations in connection with this experiment, for the year 1898, are here given:

Table showing the Diameters of the Trees and Bushes (in centimeters) at the Beginning and End of the Season of 1898.

(The plots received like applications of dissolved boneblack, muriate of potash, sulfate of magnesia, and of nitrogen in the specified forms. Measurements taken six inches above the level of the ground.)

Name of Bush or Tree.	Tree or Bush Number.	Sulfate of Ammonia.						Nitrate of Soda.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.
Orange quince*....	1	1.6	1.6	0.0	3.1	3.3	0.2	2.5	3.1	0.6	2.5	3.0	0.5
	2	1.2	1.3	0.1	2.2	2.6	0.4	1.9	2.2	0.3	2.5	3.2	0.7
	3	1.2	1.2	0.0	2.3	2.8	0.5	2.3	3.2	0.9	2.7	3.7	1.0
	4	1.6	1.6	0.0	2.3	3.2	0.9	2.0	2.6	0.6	2.4	3.1	0.7
	5	2.1	2.2	0.1	2.5	3.0	0.5	2.2	2.6	0.4	2.2	2.7	0.5
Total..		7.7	7.9	0.2	12.4	14.9	2.5	*10.9	13.7	2.8	12.3	15.7	3.4
Ave'ge Diam.\....		1.54	1.6	0.04	2.48	3.0	0.50	2.18	2.70	0.56	2.46	3.1	0.68

* Measurements one inch above the level of the ground.

Table Showing the Diameters of the Trees and Bushes (in centimeters)—Continued.

Name of Bush or Tree.	Tree or Bush Number.	Sulfate of Ammonia.						Nitrate of Soda.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.
Bartlett pear........	1	0.7	1.0	0.3	1.3	1.9	0.6	1.4	2.5	1.1	1.6	2.3	0.7
	2	1.7	2.4	0.7	1.5	2.2	0.7	2.1	2.6	0.5	1.9	2.7	0.8
	3*	1.5	1.7	0.2	1.1	2.1	1.0	0.5	1.8	1.3	2.2	3.0	0.8
	4*	1.8	2.3	0.5	2.1	2.9	0.8	1.8‡	0.6†	....	2.2	3.1	0.9
	5	1.4	2.3	0.9	1.0	1.7	0.7	1.1	1.9	0.8	2.0	2.6	0.6
Total..........	....	7.1	9.7	2.6	7.0	10.8	3.8	5.1	8.8	3.7	9.9	13.7	3.8
Ave'ge Diam.	....	1.4	1.9	0.5	1.4	2.2	0.8	1.3	2.2	0.9	2.0	2.7	0.8
Early Crawford peach.	1	3.0	5.8	2.8	5.7	8.5	2.8	5.9	8.4	2.5	4.3	6.4	2.1
	2	3.5	6.2	2.7	5.3	8.0	2.7	5.3	7.3	2.0	4.4	6.3	1.9
	3	4.5	7.1	2.6	1.2‡	4.0‡	....	5.2	8.7	3.5	4.7	6.3	1.6
	4	4.7‡	1.5†	....	4.5‡	dead	....	4.4‡	1.9†	....	4.2	6.1	1.9
	5	4.3	8.0	3.7	4.4	7.7	3.3	4.2	6.6	2.4	5.1	7.2	2.1
Total..........	....	15.3	27.1	11.8	15.4	24.2	8.8	20.6	31.0	10.4	22.7	32.3	9.6
Ave'ge Diam.	....	3.8	6.8	3.0	5.1	8.1	2.9	5.2	7.8	2.6	4.5	6.5	1.9
Golden Sweet apple.	1	2.1	2.9	0.8	2.4	3.8	1.4	2.8	4.4	1.6	3.0	4.4	1.4
	2	2.4	3.5	1.1	2.2	3.3	1.1	2.9	4.3	1.4	3.5	5.1	1.6
	3	2.6	3.7	1.1	2.9	4.7	1.8	2.5	4.0	1.5	2.8	4.0	1.2
	4	2.2	3.2	1.0	2.9	4.2	1.3	2.8	4.7	1.9	2.9	4.0	1.1
	5	2.9	4.1	1.2	3.0	4.3	1.3	2.8	4.6	1.8	2.6	3.6	1.0
Total..........	....	12.2	17.4	5.2	13.4	20.3	6.9	13.8	22.0	8.2	14.8	21.1	6.3
Ave'ge diam.	....	2.4	3.5	1.0	2.7	4.1	1.4	2.8	4.4	1.6	3.0	4.2	1.2

* Reset in the spring of 1898.

† Sprout not included in the total nor average.

‡ Omitted from averages and totals.

Table Showing the Diameters of the Trees and Bushes (in centimeters)—Continued.

NAME OF BUSH OR TREE.	Tree or Bush Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.
American white birch.	1	1.4	2.6	1.2	2.0	3.3	1.3	1.5	3.4	1.6	2.7	4.5	1.8
	2	2.4	4.6	2.2	1.1	2.9	1.8	1.9	2.9	1.8	3.1	4.6	1.5
	3	1.5	2.7	1.2	1.6	2.8	1.2	3.0	5.0	1.2	1.6	2.6	1.0
	4	1.8	3.1	1.3	2.4	4.1	1.7	2.3	2.4	0.9	1.6	3.0	1.4
	5	2.8	4.7	1.9	1.4	2.4	1.0	2.6	4.4	1.8	1.4	1.6	0.2
	6	1.4	2.8	1.4	2.0	3.2	1.2	2.0	3.3	1.3	1.7	3.2	1.5
	7	2.3	3.9	1.6	0.2*	0.9*	0.7	3.4	5.1	1.7	1.9	3.1	1.2
	8	1.7	3.4	1.7	2.6	4.1	1.5	2.6	4.0	1.4	2.1	3.7	1.6
	9	1.1	2.0	0.9	2.5	4.0	1.5	1.8	3.2	1.4	3.0	4.7	1.7
	10	1.3	3.0	1.7	1.9	3.5	1.6	1.9	3.3	1.4	2.6	4.4	1.8
Total........	....	17.7	32.8	15.1	17.7	31.2	13.5	23.0	37.0	14.5	21.7	35.4	13.7
Ave'ge diam.	....	1.8	3.3	1.5	1.8	3.1	1.3	2.3	3.7	1.4	2.2	3.5	1.3
American linden......	1	1.5	1.7	0.2	2.8	4.2	1.4	2.0	2.8	0.8	2.7	4.8	2.1
	2	1.7	2.4	0.7	2.5	3.6	1.1	2.9	4.2	1.3	2.2	3.4	1.2
	3	1.5	2.0	0.5	2.9	3.8	0.9	2.4	3.7	1.3	2.3	3.1	0.8
	4	1.7	2.1	0.4	3.4	5.2	1.8	2.9	4.6	1.7	2.5	3.9	1.4
	5	2.3	3.3	1.0	2.3	3.1	0.8	1.9	2.7	0.8	1.8	3.4	1.6
	6	2.4	3.7	1.3	2.8	4.7	1.9	1.8	2.6	0.8	2.4	3.7	1.3
	7	1.8	2.6	0.8	2.4	3.6	1.2	2.9	4.1	1.2	2.5	3.4	0.9
	8	2.1	3.2	1.1	3.2	4.7	1.5	2.6	3.9	1.3	2.1	2.8	0.7
	9	1.9	2.5	0.6	2.5	3.9	1.4	1.5	2.8	1.3	3.7	5.3	1.6
Total........	....	16.9	23.5	6.6	24.8	36.8	12.0	20.9	31.4	10.5	22.2	33.8	11.6
Ave'ge diam.	....	1.9	2.6	0.7	2.8	4.1	1.3	2.3	3.5	1.1	2.5	3.8	1.2

* Sprout included in average.

Table Showing the Diameter of the Trees and Bushes (in centimeters)—Continued.

NAME OF BUSH OR TREE.	Tree or Bush Number.	SULFATE OF AMMONIA.						NITRATE OF SODA.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.
Norway spruce......	1	2.5	3.0	0.5	2.8	3.1*	....	2.8	3.4	0.6	2.3	2.9	0.6
	2	2.6	3.5	0.9	2.3	2.7	0.4	2.0	2.5	0.5	1.9	2.8	0.9
	3	2.6	3.4	0.8	2.7	2.7†	....	2.0	3.5	1.5	2.3	2.7	0.4
	4	3.1	3.8	0.7	3.0	5.0	2.0	2.7	3.6	0.9	2.6	3.9	1.3
	5	2.3	3.0	0.7	2.3	2.9	0.6	2.5	3.1	0.6	2.2	3.2	1.0
	6	2.5	3.3	0.8	2.6	3.7	1.1	2.4	2.9	0.5	2.1	3.0	0.9
Total........	....	15.6	20.0	4.4	15.7	14.3	4.1	14.4	19.0	4.6	13.4	18.5	5.1
Ave'ge diam.	....	2.6	3.3	0.7	2.6	3.6	1.0	2.4	3.2	0.7	2.2	3.1	0.8
Baldwin apple......	1	2.0	3.3	1.3	3.0	4.5	1.5	2.6	4.1	1.5	2.7	4.5	1.8
	2	2.2	3.6	1.4	2.4	3.8	1.4	3.2	4.6	1.4	3.0	4.4	1.4
	3	1.6	2.9	1.3	3.1	4.8	1.7	2.6	4.3	1.7	3.1	4.8	1.7
	4	2.6	3.9	1.3	2.4	3.9	1.5	3.1	4.8	1.7	2.0	3.3	1.3
	5	2.9	4.6	1.7	3.3	4.9	1.6	3.2	4.8	1.6	3.2	4.9	1.7
Total.........	....	11.3	18.3	7.0	14.2	21.9	7.7	14.7	22.6	7.9	14.0	21.9	7.9
Ave'ge diam.	....	2.3	3.7	1.4	2.8	4.4	1.5	2.9	4.5	1.5	2.8	4.4	1.6
Sugar maple	1	0.9	1.2	0.3	1.3	1.8	0.5	1.5	1.9	0.4	1.0	1.5	0.5
	2	1.0	1.1	0.1	1.3	1.5	0.2	1.5	2.1	0.6	1.3	2.1	0.8
	3	1.0	1.4	0.4	1.0	1.7	0.7	1.1	1.9	0.8	1.3	2.1	0.8
	4	1.1	1.5	0.4	1.5	2.3	0.8	1.0	1.3	0.3	1.3	1.8	0.5
	5	1.0	1.6	0.6	1.3	1.3	0.0	1.1	1.7	0.6	1.5	2.2	0.7
	6	1.2	1.5	0.3	1.1	1.5	0.4	1.2	1.7	0.5	1.4	2.0	0.6
	7	1.0	1.0	0.0	1.4	2.0	0.6	1.2	1.7	0.5	1.2	2.1	0.9
	8	1.0	1.5	0.5	1.6	2.2	0.6	1.0	1.6	0.6	1.2	1.7	0.5
	9	1.1	1.5	0.4	1.1	1.9	0.8	1.4	2.5	1.1	1.4	2.1	0.7
Total........	....	9.3	12.3	3.0	11.6	16.2	4.6	11.0	16.4	5.4	11.6	17.6	6.0
Ave'ge diam.	....	1.0	1.4	0.3	1.3	1.8	0.5	1.2	1.8	0.6	1.3	2.0	0.6

* Nearly dead in autumn. Omitted from average.

† Dead. Omitted from average.

Table Showing the Diameter of the Trees and Bushes (in centimeters)—Continued.

Name of Bush or Tree.	Tree or Bush Number.	Sulfate of Ammonia.						Nitrate of Soda.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.
American elm	1	2.6	4.3	1.7	3.2	5.3	2.1	3.8	6.1	2.3	4.4	7.0	2.6
	2	2.5	4.4	1.9	3.6	5.5	1.9	3.7	5.8	2.1	4.6	6.9	2.3
	3	1.9	3.1	1.2	3.2	5.8	2.6	3.0	5.2	2.2	3.6	6.1	2.5
	4	1.8	2.8	1.0	4.7	6.2	1.5	3.0	4.9	1.9	3.5	5.5	2.0
	5	2.1	3.6	1.5	3.3	5.5	2.2	2.6	4.8	2.2	3.6	6.0	2.4
	6	2.4	3.9	1.5	3.1	4.6	1.5	3.7	6.3	2.6	3.0	5.1	2.1
	7	2.1	3.5	1.4	4.3	7.2	2.9	3.9	6.8	2.9	3.7	6.2	2.5
	8	3.2	5.5	2.3	3.1	5.1	2.0	2.6	5.0	2.4	3.3	5.2	1.9
	9	3.2	4.8	1.6	3.7	6.4	2.7	4.0	6.2	2.2	4.9	7.7	2.8
Total........	....	21.8	35.9	14.1	32.2	51.6	19.4	30.8	51.1	20.8	34.6	55.7	21.1
Ave'ge diam.	....	2.4	4.0	1.5	3.6	5.6	2.1	3.4	5.7	2.3	3.8	6.2	2.3
Burbank, Japan plum.	1	1.6	2.1	0.5	1.4	2.9	1.5	1.4	2.5	1.1	1.5	2.5	1.0
	2	1.1	1.4	0.3	1.4	2.2	0.8	1.6	2.5	0.9	1.6	2.8	1.2
	3	1.5	1.7	0.2	1.4	2.3	0.9	1.5	2.4	0.9	1.3	2.9	1.6
	4	1.4	2.2	0.8	1.6	2.5	0.9	1.7	2.9	1.2	1.5	2.9	1.4
	5	1.2	1.6	0.4	1.5	2.5	1.0	1.5	2.6	1.1	1.3	2.4	1.1
Total........	....	6.8	9.0	2.2	7.3	12.4	5.1	7.7	12.9	5.2	7.2	13.5	6.3
Ave'ge diam.	....	1.3	1.8	0.4	1.4	2.5	1.0	1.5	2.6	1.0	1.4	2.7	1.2
Early Richmond cherry.	1	1.6	1.9	0.3	1.6	2.8	1.2	1.7	2.5	0.8	1.7	2.9	1.2
	2	1.7	2.3	0.6	1.9	3.0	1.1	1.6	2.1	0.5	1.6	2.7	1.1
	3	1.6	2.3	0.7	1.7	2.5	0.8	1.7	2.6	0.9	1.6	2.6	1.0
	4	1.8	2.3	0.5	1.6	2.9	1.3	1.9	2.5	0.6	1.9	3.1	1.2
	5	1.6	2.1	0.5	1.6	2.5	0.9	1.6	2.6	1.0	1.7	2.8	1.1
Total........	....	8.3	10.9	2.6	8.4	13.7	5.3	8.5	12.3	3.8	8.5	14.1	5.6
Ave'ge diam.	....	1.6	2.2	0.5	1.6	2.7	1.0	1.7	2.5	0.7	1.7	2.8	1.1

Table Showing the Diameter of the Trees and Bushes (in centimeters)— Continued.

Name of Bush or Tree.	Tree or Bush Number.	Sulfate of Ammonia.						Nitrate of Soda.					
		Plot 23.—*Unlimed.*			Plot 25.—*Limed.*			Plot 27.—*Unlimed.*			Plot 29.—*Limed.*		
		Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.	Diameter in Spring of 1898.	Diameter in Fall of 1898.	Increase in diam.
Black tartarian cherry.	1	1.5	1.7	0.2	1.4	1.7	0.3	1.6	2.1	0.5	1.6	1.9	0.3
	2	1.5	1.9	0.4	1.5	1.9	0.4	1.4	1.9	0.5	1.8	2.0	0.2
	3	1.6	1.8	0.2	1.7	2.3	0.6	1.6	2.1	0.5	1.6	1.9	0.3
	4	1.6	1.7	0.1	1.7	2.0	0.3	1.6	2.0	0.4	1.8	2.4	0.6
	5	1.6	1.8	0.2	1.5	2.1	0.6	1.8	2.3	0.5	1.7	2.2	0.5
Total........	....	7.8	8.9	1.1	7.8	10.0	2.2	8.0	10.4	2.4	8.5	10.4	1.9
Ave'ge diam.	....	1.5	1.8	0.2	1.5	2.0	0.4	1.6	2.1	0.4	1.7	2.1	0.3

No attempt will be made here to draw any conclusions as to the action of lime or the different forms of nitrogen upon the growth of the various forest and fruit trees, since a summary of the results of the entire experiment will be given later. The results secured the past season are merely given here as a matter of record.

GRAPES.

During the winter of 1897 and 1898 a large number of the Delaware grape vines on several of the plots died, and probably the attempt to secure any further data in relation to them will have to be discontinued, or the entire lot will have to be replaced by new vines.

Early in 1898 the Concord grape vines were pruned, with the idea of establishing a system of four canes. No fruit was, however, obtained, and, in view of the unequal pruning to which they were necessarily subjected, no further attempt to measure the total new growth has been made. It is hoped that they will yield

fruit in future years, since this in the best criterion by which to judge of the relative merits of the different methods of treatment.

BLACKBERRIES. (*Snyder.*)

Since the blackberry-bushes were set upon these plots there has been every indication that they were making a better growth upon the plots which received sulfate of ammonia than upon those where nitrate of soda was applied. It has also been most interesting to observe that they appeared to do best of all upon the unlimed sulfate of ammonia plot (23), where onions, beets, asparagus, spinach, lettuce, musk-melons, timothy, and Kentucky blue-grass were total failures, and where most agricultural plants make only a meager and unsatisfactory growth. The following are the number of pounds of blackberries obtained from the respective plots:

Total Weights of Blackberries. (Pounds.)

NAME OF PLANT.	SULFATE OF AMMONIA.		NITRATE OF SODA.	
	Plot 23. *Unlimed.*	Plot 25. *Limed.*	Plot 27. *Unlimed.*	Plot 29. *Limed.*
Snyder blackberries. (Fruit)................	18.58	18.65	9.32	4.47

From the table it will be seen that the results upon the limed and unlimed sulfate of ammonia plots were far superior to those where nitrate of soda was used under corresponding conditions.

Liming appears, upon the nitrate of soda plots, to have been injurious rather than beneficial, showing that the blackberry is in this respect like lupines and common sorrel. It seems possible that the sulfur of the sulfate of ammonia may have been beneficial, or the soda of the nitrate of soda possibly noxious to the plants, or they thrive better when the nitrogen is supplied to them as ammonia. The great inferiority of the yield upon the limed

11

nitrate of soda plot, as compared with that upon the limed sulfate of ammonia plot, is of the utmost interest. This is especially true for the reason that in the case of other plants, which have shown similar tendencies, the differences have been far less. Furthermore, certain plants, such as spinach, beets, and lettuce, have always given far greater yields upon the limed nitrate of soda plot than upon the corresponding plot receiving sulfate of ammonia. The results indicate that further studies of the respective chemical, physical, and perhaps other conditions must be made before the reason for all of these peculiarities can be fully explained.

STRAWBERRIES.

The data recorded below are from potted plants set in August, 1896. A moderate yield was obtained in 1897, a record of which is given in the annual report of the Station for that year.

The following are the results obtained in 1898:

Total Weights of Strawberries. (Grams.)

VARIETY OF STRAWBERRY.	SULFATE OF AMMONIA.		NITRATE OF SODA.	
	Plot 23. *Unlimed.*	Plot 25. *Limed.*	Plot 27. *Unlimed.*	Plot 29. *Limed.*
Lady Rusk	776.9	1,280.2	1,607.6	1,879.5
Haverland	991.8	1,689.0	1,502.0	1,560.6
Charles Downing	472.5	1,168.6	741.9	635.2

It will be seen from the above table that in every case but one lime proved beneficial. The only exception was that of the Charles Downing on the nitrate of soda plots. The same was true in 1897, with one exception, but in that year the exception, though being on the same plots, was obtained with the Lady Rusk variety. Below is given the sums of the yields in 1897 and 1898:

Variety of Strawberry.	Sulfate of Ammonia.		Nitrate of Soda.	
	Plot 23. *Unlimed.*	Plot 25. *Limed.*	Plot 27. *Unlimed.*	Plot 29. *Limed.*
Lady Rusk	889.3	1,545.1	1,849.8	2,068.2
Haverland	1,050.1	2,059.2	1,739.6	1,901.7
Charles Downing	487.7	1,480.9	1,092.9	1,154.5

From a study of the total weight of fruit obtained in the two years it is seen that lime proved beneficial in the case of each of the three varieties, though the benefit from liming is far less striking than in the case of many other kinds of plants. In full accord with this, it will be seen that the strawberry was able to succeed much better than many other plants upon the unlimed sulfate of ammonia plot. From the data thus obtained it is probable that on a soil *but slightly acid* lime would prove of little or no value to the strawberry, and upon *an alkaline* soil one would reasonably expect it, if used in considerable quantity, to exert even a slightly injurious action. On very acid soils lime is, nevertheless, beneficial, and particularly so if sulfate of ammonia, and possibly other manures leaving acid residues, are employed.

Other Small Fruits.

Black-cap and Cuthbert (red) raspberries, red and white currants, and gooseberries were in bearing condition, and would probably have produced good crops, in 1898, had the blossoms not been beaten off during a heavy storm. On account of this unfortunate occurrence no further data were obtained in relation to any of these fruits. It is hoped that the next year will be favorable, and that further records can be made at that time.

Cranberry plants were set in the spring of 1898, but it is too early to obtain any data from them.

ASPARAGUS.

Asparagus plants, one year old, were set in the spring of 1897, at the rate of thirty plants to each plot. During that year many of those on the unlimed sulfate of ammonia plot died, and the balance made but little growth. Seven plants on each of the other plots also died in the course of the season. The growth on the unlimed nitrate of soda plot was much inferior to that on the limed one, and that on the latter was far better than on the limed sulfate of ammonia plot.

Owing to the fact that the plants were still quite young it was thought best not to cut any asparagus in the spring of 1898, but to allow the plants full and like opportunity for further development. For this reason, and in order that some satisfactory idea of the relative growth of the young shoots might be obtained, measurements of them were taken on May 31st. These measurements included the height from the surface of the ground of all of the shoots on each plot, and also the diameter of each shoot. In order to make the differences more apparent the sums of the height of all the shoots upon each plot are given, and, likewise, the sums of the diameters of the shoots. The total number of shoots upon each plot was also included, in order that average heights and diameters might be calculated. The following table gives the results obtained:

Observations made.	Sulfate of Ammonia.		Nitrate of Soda.	
	Plot 23. *Unlimed.*	Plot 25. *Limed.*	Plot 27. *Unlimed.*	Plot 29. *Limed.*
Number of shoots	10	74	32	102
Combined length of all the shoots*	39.30	1813.50	676.00	2708.00
Average length of shoot	3.90	24.50	21.10	26.50
Combined length of all diameters†	1.80	52.10	14.80	75.10
Average diameter	0.18	0.70	0.46	0.73

* Inches. † Centimeters. A centimeter is slightly more than three-eighths of an inch.

The small number of shoots on the unlimed sulfate of ammonia plot (23) was doubtless due chiefly to the fact that the soil was so acid as to kill many of the plants, while those which lived made but a feeble growth. The same explanation would seem to account also for the small number of plants on the unlimed nitrate of soda plot. A comparison of the measurements and the number of shoots upon the unlimed nitrate of soda plot with the corresponding figures upon the limed one shows in a striking manner the great benfit to be derived by asparagus from the use of lime upon an acid soil.

It will be seen that the growth was much greater upon the limed nitrate of soda plot than upon the corresponding one receiving sulfate of ammonia. Whether the soda in this case acted as a plant food, or whether the variation was caused largely by the difference in the reaction of the two soils, or perhaps by other factors, it is hoped will be shown later by other experiments which are in progress.

RHUBARB.

In the spring of 1897 a like number of rhubarb plants of uniform character were set upon each of the four plots. In order to give them an opportunity to become well established before removing any of the leaf stalks, no attempt to obtain any definite data was made in 1897.

On May 23, 1898, all of the stems were removed from the plants, the leaf portion cut away, as is customary for marketing, and the stems then weighed. The following are the results obtained: (See Fig. 2.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	17.0
25.	Limed sulfate of ammonia plot	67.0
27.	Unlimed nitrate of soda plot	65.5
29.	Limed nitrate of soda plot	72.0

The results from the two nitrate of soda plots show that lime was useful. Comparing the weights from the two limed plots, one

notices but little difference in the effectiveness of the two forms of nitrogen. The stalks upon the nitrate of soda plot appeared, however, to be shorter and thicker than the others.

WHITE MUSTARD.

This crop had not been previously tested on these plots. The weights of green material, as cut on August 5th, are as follows: (See Fig. 7.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	10.5
25.	Limed sulfate of ammonia plot	15.5
27.	Unlimed nitrate of soda plot	23.0
29.	Limed nitrate of soda plot	28.0

It will be noticed that lime was less useful to white mustard than to many other plants, and, in accordance with plants showing similar characteristics, it made a moderate growth upon the unlimed sulfate of ammonia plot, where poppies, beets, Swiss chard, etc., failed entirely. Nitrate of soda also proved superior to sulfate of ammonia upon the limed plots.

PARSLEY.

Parsley has been tested the past season for the first time, the variety known as "fern leaved" having been employed. On September 19 it was cut just above the surface of the ground and weighed green, with the following result: (See Fig. 3.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	0.3
25.	Limed sulfate of ammonia plot	2.1
27.	Unlimed nitrate of soda plot	2.0
29.	Limed nitrate of soda plot	2.15

Comparing the limed and unlimed nitrate of soda plots, it is evident that lime was of but little, if any, use to the parsley. Sul-

fate of ammonia used without lime proved, however, nearly fatal to it. In marked contrast to asparagus it will be seen that there was but little difference in the results upon the limed sulfate of ammonia and limed nitrate of soda plots.

SWISS CHARD.

Swiss chard had not been tested previously on these plots. It is a plant which is but little known in this State. The leaves are used as human food, the mid-ribs being cooked and eaten on toast in much the same manner as asparagus, while the balance of the leaf, or the entire portion if desired, may be prepared for the table in the same manner as spinach, dandelions, and similar plants. The crop was harvested and weighed green on July 30th. The weights are given below: (See Fig. 6.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	*
25.	Limed sulfate of ammonia plot	19.8
27.	Unlimed nitrate of soda plot	21.3
29.	Limed nitrate of soda plot	48.0

It will be seen that the yield was more than doubled by liming on the plots where nitrate of soda was used. On the unlimed sulfate of ammonia plot, in spite of the fact that the seed apparently germinated as well as upon the other plots, the crop was a total failure.

It is of much interest to compare the results on the two limed plots (25 and 29). It will be seen that the yield from the limed nitrate of soda plot was almost two and one-half times as great as upon the corresponding sulfate of ammonia plot. In this respect Swiss chard has acted much like beets, spinach, lettuce, asparagus, and several other plants.

* But two or three small plants remained alive, and these were too small to affect an ordinary balance. On an apothecary's balance they were found to weigh four drams.

CHICORY.

Chicory* in various forms has long been used as a substitute for coffee, for medicinal purposes, as salad, and for the feeding of domestic animals. For the latter purpose it has been largely superseded in Europe by alfalfa. It was employed in this experiment for the first time in 1898. The chicory roots were harvested and weighed on September 19th with the following results: (See Fig. 5.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	12.5
25.	Limed sulfate of ammonia plot	23.3
27.	Unlimed nitrate of soda plot	22.8
29.	Limed nitrate of soda plot	20.5

Comparing the results from the two nitrate of soda plots, it will be seen that a slightly less quantity of roots was obtained from the limed than from the unlimed one. Again, as has been the general rule with most other plants showing similar characteristics, it succeeded fairly well on the unlimed sulfate of ammonia plot where Swiss chard refused to grow. Another most interesting feature is the greater yield obtained from the limed sulfate of ammonia plot than from that which was limed at the same rate but which had always received its nitrogen in the form of nitrate of soda. This is particularly interesting in view of the fact that the reverse was so strikingly true of the Swiss chard.

LEEK AND GARLIC.

Neither of these plants had heretofore been tested on these plots. The garlic did not thrive, and in consequence the crop was a total failure.

Upon all of the plots the leek seed germinated satisfactorily

*The reader who wishes to know more of this plant is referred to Bulletin No. 19, U. S. Department of Agriculture, Divison of Botany, "Chicory Growing as an Addition to the Resources of the American Farmer," by Maurice G. Kasins.

Fig. 1. Broom Corn.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash, phosphoric acid and magnesia.

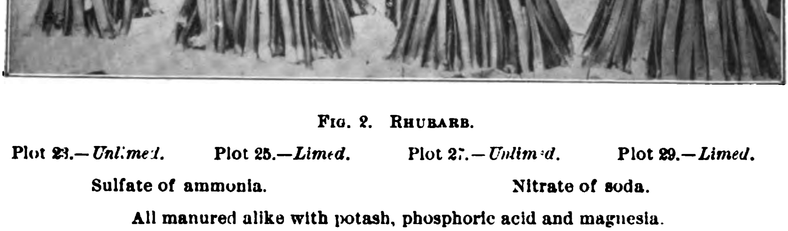


Fig. 2. Rhubarb.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash, phosphoric acid and magnesia.

FIG. 3. PARSLEY.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash, phosphoric acid and magnesia.

FIG 4. MANGEL-WURZELS.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash, phosphoric acid and magnesia.

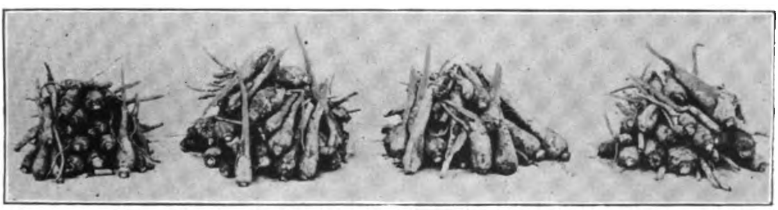


FIG. 5. CHICORY.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*

Sulfate of ammonia. Nitrate of soda.

All manured alike with potash, phosphoric acid and magnesia.

FIG. 6. SWISS CHARD.

Plot 23.—*Unlimed.** Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash, phosphoric acid and magnesia.

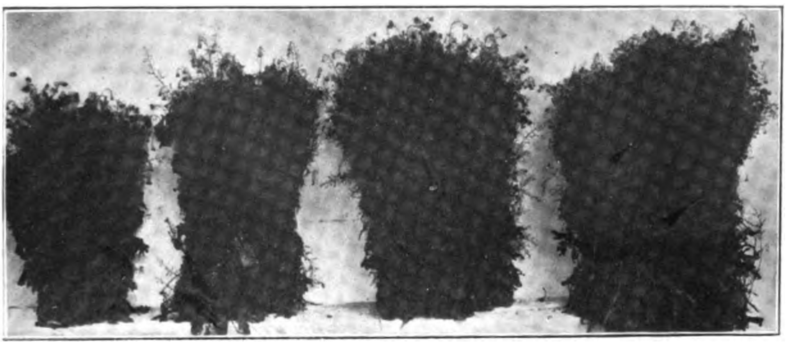


FIG. 7. WHITE MUSTARD.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash, phosphoric acid and magnesia.

FIG. 8. SWEET PEA VINES.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash, phosphoric acid and magnesia.

* All but two or three plants (too small to weigh on an ordinary balance) on the unlimed sulfate of ammonia plot (23) died, hence but three piles appear in the cut.

FIG. 9. LEEKS.

Plot 23.—*Unlimed.** Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash, phosphoric acid and magnesia.

FIG. 10. POPPIES.

Plot 23.—*Unlimed.** Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash, phosphoric acid and magnesia.

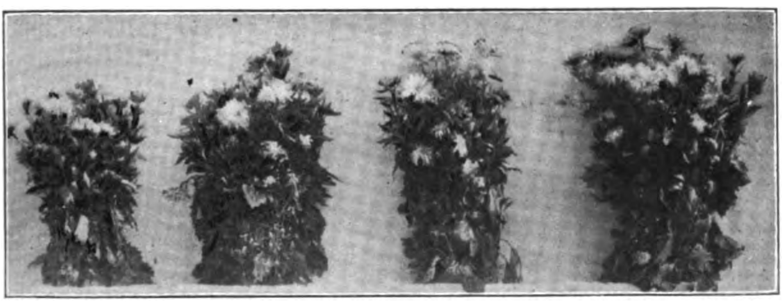


FIG. 11. ASTERS.

Plot 23.—*Unlimed.* Plot 25.—*Limed.* Plot 27.—*Unlimed.* Plot 29.—*Limed.*
Sulfate of ammonia. Nitrate of soda.
All manured alike with potash, phosphoric acid and magnesia.

* It will be noticed that but three bunches of product appear in Figs. 9 and 10; that is for the reason that in each case every plant died, when small, upon the unlimed sulfate of ammonia plot, thereby showing their great sensitiveness to the conditions which prevailed.

but nearly all the young plants eventually died upon the unlimed sulfate of ammonia plot, as did also some of those upon the unlimed plot receiving nitrate of soda. On September 19, the weight of entire plants from each plot was taken, as here recorded: (See Fig. 9.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	0.0
25.	Limed sulfate of ammonia plot	5.5
27.	Unlimed nitrate of soda plot	2.0
29.	Limed nitrate of soda plot	12.8

The leek shows a wonderful degree of susceptibility to injury by acidity, or by other unfavorable conditions existing in soil deficient in carbonate of lime. This is plainly evident from the fact that in the case of the two nitrate of soda plots the limed one produced more than six times as much as the other. Here, as in the case of the Swiss chard, the great superiority of nitrate of soda as compared with sulfate of ammonia, even upon the limed plots, is most striking.

ENDIVE.

The endive had not been previously tested on these plots. Broad leaved endive was employed and the plants were cut and weighed green on September 1.

		Pounds.
23.	Unlimed sulfate of ammonia plot	30.5
25.	Limed sulfate of ammonia plot	48.5
27.	Unlimed nitrate of soda plot	36.5
29.	Limed nitrate of soda plot	53.5

Nitrate of soda proved but moderately superior to sulfate of ammonia when both were used in connection with like amounts of lime. This plant was helped in only a small degree by liming and succeeded fairly well on plot 23, where the conditions proved fatal to a large variety of plants.

DANVERS CARROT.

In 1893, Victoria (a yellow variety) and mastodon (a white variety) carrots were grown upon these plots. In that year both crops were a little less than doubled by liming upon the nitrate of soda plots, and in both instances the limed sulfate of ammonia plot gave greater returns than the limed one receiving nitrate of soda. This was quite marked only in the case of the mastodon carrot.

In 1894 a variety of white carrot showed some benefit from liming, but gave a greater yield upon the limed nitrate of soda plot than upon the corresponding sulfate of ammonia plot. The same year two yellow varieties were grown, viz.: the Danvers and Improved Long Orange. Both of these showed injury from liming, and in the one case slight, and in the other marked superiority of growth upon the limed sulfate of ammonia plot, as compared with the limed one receiving nitrate of soda.

In 1895 a variety of carrots gave almost double the yield upon the limed that they did upon the unlimed nitrate of soda plot.

The difference between the limed nitrate of soda plot and the limed one receiving sulfate of ammonia was slight, and in favor of the former. In 1896 the results indicated some benefit from liming, though they were in certain respects too irregular to allow conclusions to be drawn from them. The limed nitrate of soda plot gave slightly better returns than the limed one to which sulfate of ammonia was applied. In 1897 carrots were not tested.

The following are the results obtained with Danvers (yellow) half long carrots in 1898:

		Pounds.
23.	Unlimed sulfate of ammonia plot	3.5
25.	Limed sulfate of ammonia plot	8.0
27.	Unlimed nitrate of soda plot	8.3
29.	Limed nitrate of soda plot	7.8

The yield was slightly greater upon the unlimed than upon the limed nitrate of soda plot, while little difference existed between the limed sulfate of ammonia, and limed nitrate of soda plots.

Taken as a whole, the experiments indicate that on a soil which is but moderately acid no great benefit from liming as compared with beets and certain other plants would be expected, except where very unfavorable physical conditions might thereby be alleviated. Where a great degree of soil acidity exists some benefit from the use of lime may be expected.

MANGEL-WURZEL.

Mangel-wurzels and other varieties of beets had been tested on these plots in previous years with practically the same result, viz.: they had always shown great benefit from liming and a much greater yield in all cases from the limed nitrate of soda plot than from the limed one receiving sulfate of ammonia. The test was repeated the past season chiefly for the purpose of ascertaining if similar results would be obtained several years subsequent to the application of the lime, and to see if the same difference would be noticeable in favor of the nitrate of soda. On June 6 seed of the "Long red" mangel-wurzel was sown uniformly upon each plot. No particular difference was noticeable in the germination of the seed upon the four plots, though soon afterwards the plants upon the unlimed plots began to die, and, notwithstanding that they were thinned at the outstart to a like number upon each plot, on July 22 only a few small plants were still alive on the unlimed sulfate of ammonia plot. On September 19 the beets were harvested and weighed, after removing the tops, with the following result: (See Fig. 4.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	0.3
25.	Limed sulfate of ammonia plot	57.8
27.	Unlimed nitrate of soda plot	54.0
29.	Limed nitrate of soda plot	87.8

It will be seen that the data are in full accord with those previously obtained, indicating the beneficial influence of lime, and also the superiority of nitrogen as nitrate when compared with

sulfate of ammonia, even when both are applied in connection with the same quantities of lime.

WATERMELON.

Watermelons had been tested on these plots on two previous occasions, and the results indicated that the plants are not easily susceptible to injury by acidity, and that quantities of lime which are highly beneficial to muskmelons may have upon watermelons an exactly opposite effect. It seemed desirable to learn, if possible, if injury from liming would result, even several years after the application was made, and after all of it had had ample time to be changed into the form of carbonate of lime.

For this reason further tests have been made the past season. The variety known as the "Phinney's new" melon was selected for the experiment. The plants were thinned to a like number upon each plot, and the vines were treated with Bordeaux mixture and Paris green to prevent injury by fungi and insects. The melons were harvested, and the vines and fruit weighed on September 17, with the following results:

		Pounds.	
		Vines.	Fruit.
23.	Unlimed sulfate of ammonia plot	90	182.0
25.	Limed sulfate of ammonia plot	70	175.0
27.	Unlimed nitrate of soda plot	90	185.5
29.	Limed nitrate of soda plot	85	237.5

It will be remembered that these plots were limed in 1893, and again in 1894, since which time no further applications have been made. Watermelons were grown on these plots for the first time in 1894, and the greatest total weight of melons was obtained from the unlimed nitrate of soda plot (27), the next greater being from the limed nitrate of soda plot. Liming evidently reduced the yield but seemed to have hastened the maturity of the crop. In that season, even though the growth of vines on the unlimed sulfate of ammonia plot was good, the limed plot produced a greater weight of fruit. In 1895 watermelons were grown again,

and most marked injury from liming was apparent. The limed nitrate of soda plot produced but 57.1 pounds as compared with 104.8 from the unlimed one, while the unlimed sulfate of ammonia plot yielded 136 pounds, and the limed one but 20.6 pounds.

From the results obtained in 1898 it will be seen, in the case of the nitrate of soda plots, that benefit rather than injury resulted from the lime which was applied four and five years previously.

In the case of the sulfate of ammonia plots a slightly smaller yield was obtained upon the unlimed than upon the limed one, yet it was too small to be considered as more than incidental, and furnishes, therefore, no positive evidence of injury from the lime even in that instance.

MUSKMELON.

Muskmelons were tested on these plots in the years 1894 and 1895. Both years a wonderful benefit from liming was noticeable, and a much greater yield was also obtained from the limed nitrate of soda plot than from the limed plot receiving sulfate of ammonia. They were grown again in 1898, chiefly as a check on the experiment with watermelons, for if muskmelons gave practically the same evidence as in former years, and watermelons showed benefit, or no marked injury, on the limed plots, there would then be more reason for the conclusion that the former injury to the watermelons was due to the caustic or strongly alkaline action of the lime which had been applied but a short time before. The variety of muskmelon employed in this experiment is that known as the "Early nutmeg." The plants were thinned to a uniform number on each plot, and were subsequently treated with Bordeaux mixture containing Paris green, as in the case of the watermelons. At the time the last of the melons were harvested the vines were also removed and weighed. The following are the weights of vines and fruit obtained:

		Pounds. Vines.	Melons.
23.	Unlimed sulfate of ammonia plot	20.0	15.3
25.	Limed sulfate of ammonia plot	40.0	106.8
27.	Unlimed nitrate of soda plot	55.0	79.5
29.	Limed nitrate of soda plot	52.5	126.8

It will be seen from the foregoing that the results obtained the past season are in full accord with those of each of the previous years, showing marked benefit from liming, and superiority of nitrate of soda as compared with sulfate of ammonia, even when each was employed in connection with like quantities of air-slacked lime.

DWARF BROOM-CORN.

Seed of the dwarf broom-corn was planted in a uniform manner on May 20, and subsequently the plants were thinned to a like number on each plot. On July 27 those upon the unlimed sulfate of ammonia plot averaged but about six inches in height, while those upon the corresponding plot, which was limed, were about two and one-half feet high. The plants upon the limed nitrate of soda plot differed but little in size from the latter, but were noticeably larger than those upon the unlimed nitrate of soda plot. On September 19 the plants were cut just above the ground and weighed, undried, with the following results: (See Fig. 1.)

		Pounds.
23.	Unlimed sulfate of ammonia plot	4.3
25.	Limed sulfate of ammonia plot	80.0
27.	Unlimed nitrate of soda plot	70.0
29.	Limed nitrate of soda plot	80.0

It will be seen that the crop was somewhat heavier upon the limed, than upon the unlimed nitrate of soda plot. Upon the unlimed sulfate of ammonia plot, where certain plants were fully or almost able to withstand the conditions, great injury to the broom-corn resulted. In marked contrast, however, to musk-melons, Swiss chard, beets, and many other plants, as good re-

sults were obtained upon the limed sulfate of ammonia, as upon the nitrate of soda plot which was limed.

ASTER.

On June 14 thirty plants per plot of the species of the comet aster, known as "The Bride," were set in a row across the four plots. The young plants had previously had the same treatment, and were so selected as to make the lots upon the four plots as uniform as possible. Subsequently several plants died, but at the time the final observations were taken there were, after discarding the customary three feet on each side of the plot, exactly seventeen plants remaining within the actual limit of the interior portion of each plot.

The first blossoms appeared on August 15, upon the limed sulfate of ammonia plot.

Owing to a sudden attack by large numbers of insects, and the probability that, even though the use of insecticides might prove practically effectual, unequal injury to the plants would doubtless result, it was decided on August 22 to cut and weigh the plants, and make observations upon the number of buds and blossoms upon the lots from the respective plots. The data thus obtained are given below: (See Fig. 11.)

		No. of buds and blossoms.	Weight of entire plants.
			Pounds.
23.	Unlimed sulfate of ammonia plot	230	2.35
25.	Limed sulfate of ammonia plot	314	3.80
27.	Unlimed nitrate of soda plot,	246	3.10
29.	Limed nitrate of soda plot	319	4.20

The observations show that lime was apparently highly beneficial, as seen both by the weight of the entire plants and by the number of buds and blossoms produced.

The results indicate no marked advantage of nitrate of soda over sulfate of ammonia on the soil in question, where a like quantity of lime was employed in connection with each.

SWEET PEA.

One row of mixed sweet peas was planted across each of the four plots on May 20. On July 22 it was observed that the smallest growth was upon the unlimed sulfate of ammonia plot; this was followed in turn by the unlimed nitrate of soda plot, the limed sulfate of ammonia plot, and finally by the limed nitrate of soda plot. Blossoms were present only on the latter plot. On July 27, or five days later, blossoms were recorded on the remainder of the plots. The blossoms were cut at frequent intervals until September 17, and a careful record kept of the number from each plot. On that date the vines were cut just above the ground and weighed at once. The weights thus obtained and the total number of blossoms cut are here given: (See Fig. 8.)

		Total number of blossoms.	Weight of vines.
			Pounds.
23.	Unlimed sulfate of ammonia plot....	616	12.5
25.	Limed sulfate of ammonia plot...	1,433	27.5
27.	Unlimed nitrate of soda plot................	1,170	22.5
29.	Limed nitrate of soda plot.	1,848	30.0

These observations indicate great benefit from the use of lime, but show, nevertheless, that the plants were able to succeed much better than many others on the unlimed sulfate of ammonia plot. In this particular they stand in striking contrast to the poppy, which failed entirely to grow upon that plot.

The weight of vines, as well as the number of blossoms, was greater upon the limed nitrate of soda plot than upon the limed one receiving sulfate of ammonia.

POPPY.

The seed of a variety of poppy known as the "Shirley" was sown on May 20, in a uniform manner, across each of the four plots. The seed germinated well in all cases, and the plants were thinned, as usual, to a like number upon each plot. Soon after

germination the plants upon the unlimed sulfate of ammonia, and nitrate of soda plots, began to die, and on July 22 every plant upon the former, and all but five upon the latter plot, had perished. On the other hand, every plant upon the limed nitrate of soda plot lived, and but one was lost upon the limed sulfate of ammonia plot.

The blossoms which appeared were cut and counted at frequent intervals, thus furnishing a record of the number for the entire period. On August 16 the plants were cut and weighed green. The data obtained by these means are given below: (See Fig. 10.)

		Total number of blossoms.	Total weight of plants.
			Pounds.
23.	Unlimed sulfate of ammonia plot	00	00.0
25.	Limed sulfate of ammonia plot	689	11.5
27.	Unlimed nitrate of soda plot	63	2.5
29.	Limed nitrate of soda plot	1,128	15.5

From the above it will be seen that the poppy is extremely sensitive to soil acidity, much exceeding carnation pinks in this respect, which, in turn, are far more liable to injury than gladiolus.

SUMMARY.

No attempt will be made at this time to give any conclusive statement in relation to the effect of lime upon the growth of the forest and orchard trees, other than to state that the indications thus far afforded go to show that lime has proved especially beneficial to the American linden, elm, and to quince bushes. It appears probable that certain trees, possibly including the white birch and Norway spruce, may be injured by liming, even on very acid soil.

This season's results with Snyder blackberries are especially interesting, for the reason that in connection with the nitrate of soda plots lime seems to have caused injury, and, furthermore, on account of the superior action of sulfate of ammonia compared with nitrate of soda as a source of nitrogen. Whether the black-

berry can better assimilate nitrogen in the form of ammonia, or whether the difference is due to some direct injury caused by the nitrate of soda, or to the difference in the chemical reaction of the soil brought about by the use for several years of these compounds, remains to be ascertained. Experiments with other plants give indications, however, that the latter theory is the more probable one, though the other factors may have contributed to the result in some measure.

Strawberries appear to have been helped by lime on our very acid soil, but it is possible that on a neutral or alkaline one injury from its use might result.

Asparagus has been wonderfully helped by lime. The superiority of nitrate of soda, as compared with sulfate of ammonia for this plant, was also most striking, affording a strong contrast, in this particular, with blackberries.

Rhubarb was apparently helped by lime, though in a small degree as compared with asparagus. Nitrate of soda also proved slightly more effective than sulfate of ammonia as a source of nitrogen.

White mustard showed moderate benefit from liming, and indicated the superiority of nitrate of soda as a form of nitrogen.

Parsley showed little if any advantage from the use of lime in connection with nitrate of soda, though on the unlimed sulfate of ammonia plot the results were extremely poor as compared with those where lime was applied. Comparing the two limed plots, but little difference in the two forms of nitrogen was noticeable.

Swiss chard, like beets, to which it is closely related, was wonderfully helped by lime, and gave far better results with nitrate of soda than with sulfate of ammonia.

Chicory was not helped, but, on the contrary, apparently injured by lime upon the nitrate of soda plots. Where sulfate of ammonia has been used continuously lime was, however, useful. Sulfate of

ammonia gave better results than nitrate of soda on the limed plots.

Leeks were helped by lime in a most striking degree, even upon the nitrate of soda plots. For this crop the superiority of nitrate of soda as compared with sulfate of ammonia, even upon the limed plots, was also marked.

Endive plants were materially helped by lime, though in a less degree than asparagus or Swiss chard. These plants showed marked ability to withstand the conditions upon the unlimed sulfate of ammonia plot where leeks and Swiss chard failed utterly. Nitrate of soda gave better results than sulfate of ammonia upon the limed plots, though the difference was less striking than in the case of many other plants.

Carrots have indicated, usually, varying benefit from liming upon our quite acid soil, but upon a neutral or alkaline one, heavy applications might exert injury.

It would seem to be wise to introduce this crop into a rotation two or three years after liming, an idea which is suggested by occasional injury noticed soon after lime was applied.

Mangel-wurzels fully corroborated the experience of previous years, showing striking benefit from the use of lime, and great superiority of nitrate of soda over sulfate of ammonia when nitrogen in these forms is employed in like amounts and under identical conditions.

Watermelons give indication that the great injury otherwise resulting from liming can probably be avoided if the melons are introduced into the rotation three or more years after the lime is applied.

This season nitrate of soda proved, when used without lime, but slightly better than sulfate of ammonia, though on the limed plots the nitrate form of nitrogen was much superior.

Muskmelons have fully agreed with the tests in former years, indicating great benefit from liming, and the superiority of nitrogen in the form of nitrate of soda.

Dwarf broom-corn was helped moderately by liming, and on the limed plots the results were identical in the case of both forms of nitrogen.

Comet aster ("The Bride"), though it was helped by lime, even in connection with nitrate of soda, showed, nevertheless, wonderful ability to withstand the acid condition existing on the unlimed sulfate of ammonia plot where so many other kinds of plants entirely failed. But little difference was noticed between the action of the two forms of nitrogen.

Sweet peas showed marked advantage from the employment of lime, as shown by the increased weight of vines, and especially by the great increase of blossoms. Many more blossoms and heavier vines were produced by nitrate of soda than by sulfate of ammonia upon the limed plots.

Poppies seemed to be wonderfully helped by lime, as indicated by the number of blossoms and by the total weight of the plants. Nitrate of soda proved far superior to sulfate of ammonia as a source of nitrogen for this plant.

A FURTHER STUDY OF THE LIME REQUIREMENT OF RHODE ISLAND SOILS.

H. J. WHEELER AND G. E. ADAMS.

Prior to the establishment of the Agricultural Experiment Station in this State, few, if any, apparently believed that our soils were generally in need of treatment with lime. Wood ashes had long been used to some extent with excellent results, but their beneficial action was attributed almost solely to the potash which they contain. A few incidental observations on the ill effect of sulfate of ammonia upon the farm of Mr. H. E. Lewis, at Hope Valley, and at the Experiment Station, led to the idea that lime was needed. This view became so strengthened in succeeding years that an experiment with beets was conducted on the farm of Mr. F. P. Babcock, at Westerly, in 1895, to test the soil in this particular. The remarkable benefit from liming noticed in this instance led to the inauguration of a large number of experiments, in various portions of the State, in 1896. These gave every indication that the need of lime was not confined to the Experiment Station farm, but that, contrary to the view of many skeptics, the condition was more or less general throughout the State.*

In 1897 some of the experiments, begun the previous season, were continued, and a few new ones were made in other localities. The result of these observations,† with grasses, clover, and beets, fully confirmed the experience of the previous year, and gave an additional incentive to the continuation of this line of coöperative investigation.

* See Ninth Annual Report, R. I. Agricultural Expt. Station (1896), pp. 282-298.

† See Tenth Annual Report, R. I. Agricultural Expt. Station (1897), pp. 185-201.

The promise of further usefulness of the coöperative experiments has now become so great that their future continuance by the Station, at least for a few years, would seem to be imperative. Of the former experiments those at Hamilton and Summit have been continued in 1898, in accordance with the desire of the gentlemen upon whose farms they were being conducted. In order to study the needs of as many sections of the State as possible, further experiments have been inaugurated the past season at Boston Neck, North Scituate, Diamond Hill, Warren, Tiverton Four Corners, Jamestown, Kenyon, and Wood River Junction.

Detailed descriptions of the individual experiments follow:

Experiment on the Farm of Geo. H. Larned, Hamilton, R. I.

This experiment comprised two plots, each 27 feet square, one of which was limed in 1896 at the rate of about 2½ tons per acre. Each plot was divided at the outstart into two sections. One section of each plot was sown with barley and clover, and the remaining sections were devoted to table beets, the manuring having been alike in all cases. After the removal of the beets those sections were seeded, the same autumn, to timothy and redtop, so that in 1897 one side of each plot produced clover (mixed with grass which came in naturally), and the other side, timothy and redtop. In 1897 the sections were manured alike, so far as concerned potash and phosphoric acid, but the clover sections were given much less nitrogen in form of nitrate of soda than the others, for the reason that clover can assimilate the nitrogen of the atmosphere.

In the spring of 1898 each of the four sections was top-dressed with the following:

1.25	pounds	nitrate of soda.
0.75	"	muriate of potash.
3.50	"	acid phosphate.

The rates per acre were as follows: nitrate of soda, 150 pounds; muriate of potash, 90 pounds; and acid phosphate, 420 pounds.

The grass upon the four sections was cut and weighed green on June 28, 1898.

The limed section originally in clover contained but few clover plants, with some meadow oat grass, and about 90 per cent. of the herbage appeared to be redtop. Upon the *unlimed* clover section clover was wholly lacking. The grass was practically all redtop mixed with a little narrow leaved plantain (*Plantago major*). Upon the limed grass section the growth of timothy was good, this grass constituting apparently about 80 per cent. of the herbage. The individual plants and the size of the stools were much larger than those upon the unlimed section. The balance of the herbage on the section was redtop.

Upon the *unlimed* grass section the growth of timothy was poor, and only about 10 per cent. of the herbage consisted of this grass, the balance being mostly redtop with traces of meadow oat grass. The yields of undried material were as follows: (See Figs. 1 and 2.)

	Limed. *Pounds.*	Unlimed. *Pounds.*
From the clover section	107.0	72.9
From the grass section	100.9	67.8

The percentage gain due to liming on the clover sections was 46.8, and on the grass sections, 49.9.

It may seem surprising, to one who studies these results carefully, that on the limed clover section timothy did not appear naturally, just as redtop did. This is particularly true in view of the beneficial action of lime upon the growth of the former grass. It must be borne in mind, however, that the conditions for the growth of timothy upon this soil had long been unfavorable, and if timothy seed had ever fallen upon the land it had probably germinated and the young plants died in former years without maturing further seed. On the contrary, the conditions had remained favorable to the growth of redtop, so that more or less of this grass had undoubtedly propagated itself in the course of the previous years. This seems to have been merely a case of the survival of that species which could endure on an acid soil.

Experiment on the Farm of B. H. Nixon, Summit, R. I.

Two plots, each 27 feet square and divided into two sections each, were employed in this experiment.

In the spring of 1896 one plot was limed at the rate of, approximately, 2½ tons per acre. The treatment of each of the four sections was in all respects the same in 1896 and 1897 as that of the corresponding clover and grass sections in the experiment upon the farm of Mr. Geo. H. Larned, of Hamilton, previously described.

In the spring of 1898 the two grass sections were each top-dressed with the following:

1.25	pounds	nitrate of soda.
0.75	"	muriate of potash.
3.50	"	acid phosphate.

On July 6 the grass on both sections was cut and weighed green.

In the case of the limed section the grass was almost wholly timothy, except along the edges, where some redtop was to be seen.

The herbage upon the *unlimed* plot consisted, on the contrary, almost wholly of redtop with only here and there a few timothy plants. The following are the yields of undried grass upon the two sections: (See Fig. 5.)

Limed section (mostly timothy)	49.8 pounds.
Unlimed section (mostly redtop)	45.6 pounds.

The chief advantage from liming, in this instance, was that the limed plot produced a better horse hay and a product having a superior money value per ton.

The two sections of these plots which were in clover in 1897 were plowed in the spring of 1898, and each received the following manures:

2.5	pounds	nitrate of soda.
2.5	"	muriate of potash.
7.5	"	acid phosphate.

Fig. 1. Grass (Timothy and Redtop sections).

HAMILTON, R. I.

Limed. ***Unlimed.***

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 2. Grass (chiefly Redtop) on former clover sections.

HAMILTON, R. I.

Limed. ***Unlimed.***

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 3. Timothy.

NARRAGANSETT PIER, R. I.

Limed. ***Unlimed.***

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 4. Timothy.
MOOSUP VALLEY, R. I.

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 5. Grass (Timothy and Redtop).
SUMMIT, R. I.

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

Fig. 6. Red Table Beets.
ARNOLDS MILLS, R. I.

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

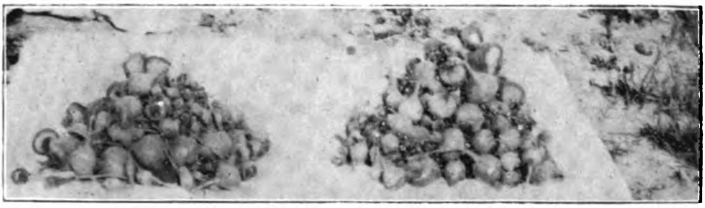


FIG. 7. RED TABLE BEETS.
KENYON, R. I.
Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG. 8. RED TABLE BEETS.
WARREN, R. I.
Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

FIG. 9 MANGEL-WURZELS.
JAMESTOWN, R. I.
Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

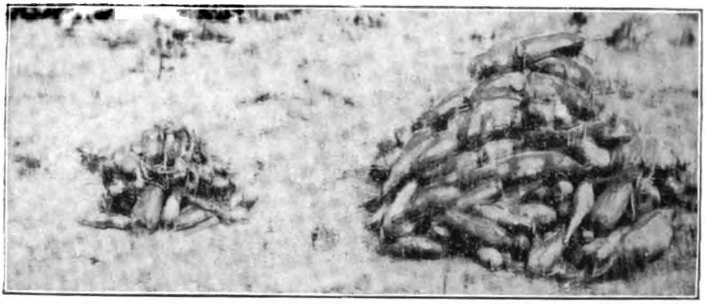


FIG. 10. MANGEL-WURZELS.

WOOD RIVER JUNCTION, R. I.

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

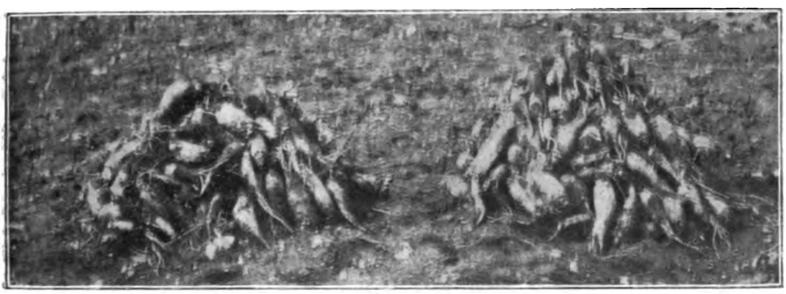


FIG. 11. MANGEL-WURZELS.

TIVERTON FOUR CORNERS, R. I.

Unlimed. *Limed.*

Both plots manured alike with potash, phosphoric acid and nitrogen.

Six rows of red table beets were planted across the limed and unlimed sections.

This experiment was located upon a gravelly knoll, and in consequence of excessively hot, dry weather, at certain periods, the beets upon both plots made but little growth. Upon harvesting, on September 21st, the following weights were obtained:

	Pounds.
Table beets from limed section	13.4
Table beets from unlimed section	4.0

In 1896, when these sections were planted to table beets, 92.9 pounds were obtained from the limed plot, and 47.4 pounds from the unlimed one.

Experiment on the Farm of John F. James, Moosup Valley, R. I.

In 1897 two plots, each 12 x 30 feet, were laid out in an old exhausted pasture. One plot was treated with air-slacked lime at the rate of 4,920 pounds per acre. Each plot was manured as follows:

	Pounds per plot.	Pounds per acre.
Nitrate of soda	2.5	300
Muriate of potash	2.5	300
Dissolved boneblack	7.5	800

From the limed plot 174 pounds, and from the unlimed plot 25.3 pounds of mangel-wurzels were harvested. After removing the beets both plots were seeded with like amounts of timothy seed. In the spring of 1898 each plot was top-dressed with the following manures:

1.25 pounds nitrate of soda.
0.75 " muriate of potash.
3.50 " acid phosphate.

On the limed plot the growth was fair, and the herbage consisted chiefly of timothy, with here and there a few rushes.

The herbage upon the *unlimed* plot consisting chiefly of common sorrel, associated to some extent with rushes. So near as could be estimated, but about 5 per cent. of the bulk of the herbage consisted of timothy. The following are the weights of green material as harvested (see Fig. 4):

Material from limed plot....................................	51.8 pounds.
Material from unlimed plot..................................	24.8 pounds.

From the above notes it will be seen that, owing to the large proportion of weeds upon the unlimed plot, the actual gain from liming was much greater than would appear from the record of total weights of produce.

Experiment on the Farm of Thomas G. Hazard, Boston Neck, R. I.

Two plots, each 12 x 30 feet, were employed in this experiment. One plot was limed in the fall of 1897, at the rate of 1,500 pounds per acre. At the time the lime was worked into the soil, the unlimed plot was raked and treated in every respect like the limed one. Timothy seed was sown in the fall at a uniform rate upon both plots.

During the succeeding winter each plot was top-dressed with like quantities of sea-weed of uniform character. On June 20 no marked difference between the growth upon the two plots was noticeable. July 8, the grass upon both plots was cut and weighed. In cutting the grass upon the remainder of the field a narrow strip had been mown by accident upon one end of the limed plot. For this reason a section two and one-half feet wide was discarded from the end of each plot before the weights were taken. Since the visit on June 20 the grass upon the limed plot had made a much better growth than that upon the other one. The herbage consisted of practically pure timothy. The weights of undried grass from like areas were as follows (see Fig. 3):

Limed plot..	177.9 pounds.
Unlimed plot..	122.3 pounds.

The gain from liming in this instance amounted, therefore, to 45.5 per cent.

It is hoped to continue this experiment with the purpose of testing the relative yields in coming years, but more especially to see if the unlimed plot will become occupied by other grasses sooner than the limed one.

Near Narragansett Pier, as in other places where there is a demand for a superior quality of hay for feeding to horses, it is of material value if the land can be so treated as to make it more retentive of timothy to the exclusion of redtop, Rhode Island bent, and other grasses.

Coöperative Experiments with Beets, begun in 1898.

These experiments were conducted upon the following farms:

Edwin A. Mason, Warren, R. I.
Benj. F. Smith, North Scituate, R. I.
Isaac C. Ellis, Wood River Junction, R. I.
Jason Newell, Arnold's Mills, R. I.
W. King & Son, Kenyon, R. I.
Theo. B. Stork, Jamestown, R. I.
Chas. H. Potter, Tiverton Four Corners, R. I.

The plots upon the farm of Benj. F. Smith, of North Scituate, were 27 x 13½ feet; all of the others, excepting those on the farm of Mr. Mason, were 12 x 30 feet. Mr. Mason's plots were but half as large as the others. The manures applied to all of these plots were identical in kind. The limed plot in each experiment was dressed at the rate of 41 pounds for each plot twelve feet by thirty, or, in other words, at the rate of about 2½ tons per acre. The rate of application of the other manures per acre was the same in all cases, requiring per plot, 12 x 30 feet, the following:

2.5 pounds muriate of potash.
2.5 " nitrate of soda.
7.5 " acid phosphate.

Table Showing the Effect of Air-slacked Lime Upon the Growth of Beets in Various Sections of Rhode Island. (See Figs. 6 to 11, inclusive.)

LOCATION OF EXPERIMENT AND NAME OF COÖPERATING PERSON.	LIMED. *Pounds.*	UNLIMED. *Pounds.*
Edwin A. Mason, Warren	36.5*	16.5*
Benjamin F. Smith, North Scituate	236.0†	201.0†
Isaac C. Ellis, Wood River Junction	75.5†	8.1†
Jason Newell, Arnold's Mills	33.1*	11.8*
W. King & Son, Kenyon	18.8*	13.4*
Theo. B. Stork, Jamestown	180.9†	28.5†
Charles H. Potter, Tiverton Four Corners	137.8†	106.3†

Owing to periods of extremely hot weather and accompanying drought, the beets in some instances made a very poor growth. This was much more severe upon the newly turned sward than upon other land, it being especially marked at Arnold's Mills and Kenyon. Nevertheless, unmistakable benefit from liming was noticeable in both instances. The wonderful benefit from liming in connection with the Wood River Junction and Jamestown soil gives every indication that the character of those soils and their adaptability for certain crops may be entirely transformed by liming.

Mr. Mason, of Warren, was desirous of testing his soil as to the effect of lime upon the growth of lettuce and spinach. For this purpose he tried both crops under like conditions as regards manuring and other particulars, running the rows across both the limed and unlimed plots. He states that "The weight of dry lettuce stalks was 1¼ pounds on the unlimed, and 1⅞ pounds on the limed plot." In regard to the spinach, he says: "Both rows came up all right, but on the unlimed plot it soon began to turn yellow and die, and on October 3d there was but one plant left.

* Red table beets.

† Mangel-wurzels.

This plant was about four inches high and looked bright, but did not throw up any seed stalk. On the limed plot every plant lived and grew from twenty to twenty-four inches tall, ripening its seed."

SUMMARY.

The experiments of this season fully confirm the opinion that a need of lime is much more universal in Rhode Island than has been generally supposed.

NOTE.—Since ordinary builders' lime can be slacked and used for liming land, just as well as air-slacked lime, there is no reason why all who wish to try it in a small way at first should not do so. Some plants are injured by it; so in making a test one should use some crop like beets which responds readily to its application. Any person wishing Bulletin 46, on Lime and Liming, in which full directions for such tests and for the use of lime may be found, can obtain a copy free by forwarding a request for the same, accompanied by his post-office address, to the Rhode Island Agricultural Experiment Station, Kingston, R. I.

TRIALS OF VARIETIES OF POTATOES.

J. A. TILLINGHAST AND H. J. WHEELER.

Plot 41, of the experimental grounds, which had previously received uniform treatment in every way, was selected for the trial. The soil is a rather heavy loam, with a small admixture of sand.

The following fertilizer was used, three-quarters being applied broadcast and harrowed in, the other one-quarter strewn in the furrow and thoroughly mixed with the soil: Nitrate of soda, 105 lbs.; tankage, 750 lbs.; dissolved phosphate rock, 397.06 lbs.; fine ground bone, 120 lbs.; and muriate of potash, 300 lbs.; a total application of 1,672.06 lbs. per acre.

With the exception of four varieties of German salad potatoes, which, being very small, were planted without cutting, the sets were cut to two eye pieces, placed fifteen inches apart in furrows three feet apart, and covered to a depth of four inches. The cultivation was the same for all of the varieties.

To protect from beetles and blight they were sprayed with Paris green and Bordeaux mixture on July 1st, 14th, 25th, and August 1st. At the latter time it was noted that some of the German varieties, especially the Prof. Dr. Maercker, showed great resistance to the action of the blight; very much more than any of the American varieties.

The trial of these varieties will be continued, to ascertain, if possible, whether or not the blight resisting power will be retained when grown for several successive seasons in our soil and climate.

A part of each early variety was dug on August 3d. (See Table I.) The remainder and the later varieties were dug on September 30th. (See Table II.)

Tubers weighing over two ounces are classed as large, excepting the four last named salad varieties in Table II, which are of small size, a characteristic and most desirable feature of potatoes grown especially for salad purposes.

TABLE I.

Showing Yields of Early Varieties. Planted May 10th, and Harvested August 3d, 1898.

VARIETY.	Number of Tubers Harvested.			Yield of Tubers in Pounds.			Yield of Tubers in Bushels per Acre.		
	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.
Early Michigan	118	57	61	14.5	11.8	2.7	255.2	207.7	47.5
Early Market	60	41	19	11.3	10.3	1.0	198.9	181.28	17.62
Queen	135	47	88	13.8	9.3	4.5	242.9	163.7	79.2
Early Andes	151	56	95	13.3	8.8	4.5	234.1	154.9	79.2
Bovee	131	48	83	13.0	8.5	4.5	228.8	149.6	79.2
Early Fortune	116	43	73	11.0	7.5	3.5	193.6	132.0	61.6
Early Six Weeks	87	33	54	9.8	6.3	3.5	172.5	110.9	61.6
Paulson's Juli	175	14	161	9.8	2.0	7.8	172.5	35.2	137.3
Early Dawn	40	15	25	4.0	2.5	1.5	154.9	96.5	58.4
Toogood's Ashleaf	98	00	98	2.5	0.0	2.5	44.0	0.0	44.0

TABLE II.

Showing Yields of Varieties. Planted May 10th, and Harvested September 30th, 1898.

VARIETY.	NUMBER OF TUBERS HARVESTED.			YIELD OF TUBERS IN POUNDS.			YIELD OF TUBERS IN BUSHELS PER ACRE.		
	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.
Early Michigan	152	57	95	17.5	11.5	6.0	308.0	202.4	105.6
Early Market	78	42	36	11.0	10.5	2.5	193.6	184.8	8.8
Queen	146	78	68	17.5	13.5	4.0	308.0	237.6	70.4
Early Andes	148	43	105	15.3	9.0	6.3	269.3	158.4	110.9
Bovee	106	51	55	15.8	11.8	4.0	269.3	198.9	70.4
Early Fortune	150	51	99	16.0	9.5	6.5	281.6	167.2	114.4
Early Six Weeks	77	41	36	11.0	8.5	2.5	193.6	149.6	44.0
Paulson's Juli	193	15	178	12.5	2.5	10.0	220.0	44.0	176.0
Early Dawn	61	24	37	6.8	4.3	2.5	263.3	166.5	96.8
Toogood's Ashleaf	186	0	186	7.5	0.0	7.5	132.0	0.0	132.0
Prof. Dr. Maercker. (From Germany)	439	96	343	40.0	20.0	20.0	336.7	168.4	168.3
Prof. Dr. Maercker. (From Bohemia)	541	138	403	47.5	26.5	21.0	399.8	223.1	176.7
Dr. Von Lucius	241	51	190	30.5	14.0	16.5	256.7	117.8	138.9
Toogood's Tremendous	199	17	182	13.5	2.5	11.0	113.6	21.0	92.6
New Main Crop	106	61	45	12.0	10.0	2.0	101.0	84.2	16.8
Vigorosa	241	107	134	34.5	25.0	9.5	290.4	210.5	79.9
Joseph	206	135	71	36.5	31.5	5.0	307.2	265.1	42.1
Enormous	220	124	96	38.0	32.5	5.5	319.8	273.5	46.3
Hampton Beauty	201	100	101	31.8	24.3	7.5	267.7	204.5	63.2
SALAD VARIETIES.									
Gloria	....	....	....	23.3	20.5	2.8	98.1	86.3	11.8
Mäuschen	....	....	....	8.8	8.0	0.8	87.0	83.6	3.4
Nieren Marjolin	....	....	....	30.3	27.5	2.8	84.9	77.1	7.8
Nieren röthliche	....	....	....	8.8	8.0	0.8	87.0	83.6	3.4

DESCRIPTION OF VARIETIES.

The following named varieties were selected to test again, from among the best varieties grown in 1897, and a full description of them will be found on pages 387 and 388 of the Annual Report for that year: Vigorosa, Joseph, Enormous, Hampton Beauty, Bovee, and Early Six Weeks.

NEW VARIETIES, 1898.—*Early Michigan.* Tops medium size, vigorous, slightly spreading. Strong stems, standing up well. Little blight. Tubers oblong, white, smooth and handsome. At first harvesting, this variety gave the largest yield of marketable tubers and the greatest total yield.

Early Market. Tops erect, fairly vigorous and large leaved. Slightly affected by blight. Tubers oblong, dun colored, with small russet spots, and of good size.

Early Andes. Tops somewhat spreading, fairly vigorous. Leaves large. Blighted considerably. Tubers light dun color, slightly oblong to round, rather uneven in size. Eyes shallow.

Early Fortune. Tops wide spreading, branches large and very leafy. A very green thrifty growth, but blighted easily. Tubers light dun color, oblong, flattened. Shallow eyes, and quite even in size and shape.

Paulson's Juli. Tops medium size, somewhat procumbent, very even in general appearance. Less easily affected by blight than some of the other early varieties. Tubers white, oblong, slightly flattened. Small size. Eyes shallow. Seed tubers imported from Göttingen, Germany.

Early Dawn. Tops rather small and spreading. Leaves large. Considerable blight. Tubers dun color, round or slightly oblong. Eyes rather deep. Size medium.

Toogood's Ashleaf. An early English variety. Tops very small,

slender, and light in color. Very little affected by blight. Tubers white, oblong, flattened. Eyes very shallow. Size medium. Seed tubers imported from England.

Toogood's Tremendous. A late English variety. Tops fairly vigorous, erect, medium size, though somewhat uneven in growth. Quite free from blight. Tubers white, oblong or kidney shaped. Medium size. Eyes shallow. Seed tubers imported from England.

New Main Crop. Tops fairly erect, thrifty, dark green, and very even in appearance. Blighted very little. Tubers bright dun color, round to oblong, slightly flattened, and of good size. Eyes rather deep.

Dr. Von Lucius. A German variety. Tops tall, strong, and upright. Rather light in color. Blossoms, many in number, white, and above medium size. Did not blight easily. Tubers white, round and rather uneven in size and shape. Eyes deep. Seed tubers kindly donated, as were also some of the Prof. Dr. Maercker, by Augustus von Doerr, Smilkau, near Woltitz, Bohemia.

Prof. Dr. Maercker. Top very strong and vigorous. Upright, strong stems. Blossoms quite plentiful, color light purple. Tubers white, round, slightly flattened, yellow-fleshed. Classed as medium early in Germany, though it should probably be considered a later variety here. Seed tubers of this variety were obtained from both Germany and Bohemia. Little difference could be discerned, except that those from Bohemia produced a somewhat larger growth of tops, and a more even size of tubers. This variety showed much greater power to resist the attacks of blight than any of the other varieties tested.

Gloria, Mäuschen, Nieren Marjolin, and *Nieren röthliche* are varieties of salad potatoes. The seed tubers were obtained from Germany.

The tops are very small and spreading, and withstood the blight well during this, their first season's trial here. The tubers are

small, long in shape, and the flesh yellowish. In cooking they do not become "mealy" but retain their form as prepared, thus making them particularly suitable for salad use.

In a cooking test in which they were compared with the small tubers of the New Queen variety, the German salad varieties proved far superior in every respect for salad purposes.

TRIAL OF "NITRAGIN."

H. J. WHEELER AND J. A. TILLINGHAST.

It is well known that leguminous plants have the power to gather nitrogen from the air, through the agency of minute organisms which develop upon the roots.*

If these organisms, known as bacteria, are not present, the legumes have not the power to gather nitrogen from the air for their own use, and also for other plants which succeed them.

Fields in which a certain leguminous plant has failed to thrive, owing to a lack of the necessary bacteria, have sometimes been inoculated by strewing upon them soil from some other field where that particular variety of legume has been found to flourish.

When inoculated in this way with soil, it should be worked in at once to a depth of three or four inches, to prevent drying, which would be fatal to the bacteria. This method is, however, somewhat expensive, and to easily and cheaply inoculate fields deficient in these organisms, pure cultures of bacteria, designed for the various leguminous plants, are prepared, according to the plan of Prof. Nobbe, and placed on sale under the name of "Nitragin."

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* Ville claimed many years ago that certain plants were capable of assimilating atmospheric nitrogen. Subsequent experiments, by Boussingault and others, appeared to disprove Ville's work.

More recently Atwater obtained results with legumes apparently confirmatory of Ville's results. But it remained for Hellriegel and Wilfarth to fully demonstrate the ability of leguminous plants to assimilate atmospheric nitrogen, and to show that this takes place only through the agency of a bacterium, or bacteria, having their seat upon the roots of the plants. These minute organisms cause the nodular development often observed upon the roots of many kinds of leguminous plants, as peas, beans, clover, &c.

PEA VINES.—*First Crop.*

The vines on the left were from a plot not treated with "nitragin." But few nodules were found on the roots of the plants from the untreated plots, only one large one having been noticeable upon the plant at the left. The roots of the plants on the extreme right, which came from the plot inoculated with "nitragin," were, on the contrary, practically covered with very small nodules, which may be readily seen.

The results of a trial of this material, prepared especially for peas, are given below.

On June 11th, four plots, containing 100 square feet each, were laid out upon soil of even quality, and where leguminous plants had not previously been grown for 20 or more years. Each plot received broadcast per acre:

Muriate of potash	300 pounds.
Acid phosphate	800 pounds.
Plots 3 and 4, air-slacked lime	3,000 pounds.

The fertilizer and lime were thoroughly worked into the soil. The culture, after being warmed according to directions, was divided into two equal parts, each part being thoroughly mixed with one gallon of water of suitable temperature.

One portion was sprinkled upon plot 1, and the other upon plot 3, and immediately worked into the soil.

The morning selected for the application was cloudy, and thus the culture was not exposed to the direct rays of the sun, which prove fatal to the organisms.

Every precaution possible was taken to prevent plots 2 and 4 from becoming inoculated in any way, either at the time of planting or in the after cultivation.

Four rows of American Wonder peas were planted on each plot, using equal weights of seed on each.

On July 29th, the peas having made their full growth, and being just at the point of ripening, were cut close to the ground. The weights, taken green, were as follows:

Plot 1 (nitragin)	12.25 pounds.
Plot 2 (no nitragin)	15.15 pounds.
Plot 3 (nitragin, lime)	12.55 pounds.
Plot 4 (no nitragin, lime)	12 95 pounds.

The roots were then carefully loosened, by means of a fork, and pulled.

Upon plot 1 (nitragin), the roots were thickly covered with small nodules.

Upon plot 2 (no nitragin), although the vines were of larger growth and weighed more, yet, upon a careful examination of the roots, but 21 nodules were distinguishable, and these were much larger and very irregular in shape as compared with those upon the roots of the plants where nitragin was applied.

Upon plot 3 (nitragin and lime), many nodules were found upon the roots, and very little, if any, difference could be discerned in this respect between this and the unlimed nitragin plot.

Upon plot 4 (no nitragin, lime), while the yield was about the same as upon the other plots, a careful search failed to reveal any discernible nodules upon the roots of the plants.

To still further test the effects of the nitragin, the plots were immediately planted in exactly the same manner with Shropshire Hero peas, a medium early variety, and the same care was exercised in every way to prevent plots 2 and 4 from becoming inoculated with the bacteria from the other plots.

The second crop of peas made an excellent growth, and on September 29th many of the pods were well filled.

On this date they were harvested in the same manner as the first crop, and weighed green with the following results:

Plot 1 (nitragin)	17.75 pounds.
Plot 2 (no nitragin)	24.25 pounds.
Plot 3 (nitragin, lime)	17.00 pounds.
Plot 4 (no nitragin, lime)	20.50 pounds.

The roots were then carefully loosened and pulled. Nodules were found in large numbers on all of the plots. There were apparently more on plot 2 than on plot 4 (both without nitragin), yet on neither of these were they quite so abundant as on plots 1 and 3, which had received it.

The very even yield of the first crop upon all of the plots, with the exception of plot 2, which, for some reason, gave slightly larger yields in both crops, would indicate that the crop on this particular soil, obtained sufficient nitrogen to supply its needs without reference to any effect of the nitragin.

In the case of the first crop no essential difference in yield was

noticed between plot 3 (with nitragin) and plot 4 (without nitragin); but in case of plots 1 and 2, a greater yield was obtained from plot 2 without than from plot 1 with nitragin.

In the case of the second crop, the plots treated with nitragin gave smaller yields in both cases than those to which it was not applied. The least difference was noticeable in the case of 3 and 4, which gave practically identical yields with the first crop.

Owing to the fact that no reasonable ground for injury from the employment of nitragin suggests itself, it seems probable that the smaller yields upon the plots to which it was applied were incidental and due to naturally existing inequalities in the soil which could not have been foreseen, and which were not manifest before the experiment was begun.

For the reason that leguminous plants can draw their supply of nitrogen from compounds of that element already existing in, or artificially applied to, soils, it would not be surprising if, in the presence of an abundance of the same, they should not form many nodules nor assimilate any considerable quantity of atmospheric nitrogen. This may explain why more nodules were found upon the roots from the inoculated plots in the second than in the first crop, particularly in view of the fact that the first crop may have utilized most of the directly assimilable nitrogen compounds pre-existing within the soil.

Assuming that there were some of the organisms already existing in the soil, it would not be surprising if the roots of the second crop should have been thoroughly infested with nodules, while but a few incidental ones on either of the plots were observable upon the roots of the first crop.

In order to prevent, if possible, the transferring of the organisms from the inoculated to the uninoculated plots by natural means, paths two feet wide were left between the plots. If, therefore, the soil of the plots not treated with nitragin became inoculated from those that were, there is strong evidence of a much greater and more rapid lateral movement in the soil of these organisms than would seem probable.

It was observed, furthermore, that vast numbers of nodules were distributed uniformly upon the roots from all parts of the plots not treated with nitragin.

Had inoculation of the untreated plots taken place through a lateral movement of the organisms within the soil, it would have seemed probable that the plants upon the edges of the plots nearest to the point from which inoculation was supposed to proceed would have possessed more nodules, or have developed more rapidly than those farther removed therefrom. In consideration of all these points it seems probable that the failure of the nitragin to show any benefit may have been due solely to the fact that enough of the organisms were present in the soil so that any further addition of them became unnecessary and useless.

The large number of nodules found upon the roots of the plants, in the first crop upon the plots which were inoculated with nitragin, might be considered as an indication that there were not at the outstart a large number of the organisms naturally existing in the soil. Even if this were the case, it is not improbable that where no nitragin was applied their numbers might have increased before the second crop was grown to such an extent as to insure an abundance of nodules upon the roots of the second crop, and, as previously mentioned, there was doubtless enough readily assimilable nitrogen present so that the first crop was able to attain full development without their intervention and the assimilation of atmospheric nitrogen.

Summary.

It seems probable that the absence of any particular benefit in the case of the first crop was due to the presence of sufficient combined nitrogen in an assimilable form to supply the needs of the plants.

The lack of apparent benefit in the case of the second crop was probably due in part to the cause just mentioned, and to the fact that the organisms naturally present had multiplied to such an

extent as to insure an abundant assimilation of atmospheric nitrogen without the intervention of those supplied by the nitragin.

That the nitragin would have been efficacious in a soil which did not contain the organisms seems unquestionable, in view of the fact that in the first crop the roots of the plants where it was used were infested with immense numbers of nodules, thus showing, in contrast with the untreated plots, that infection by its means had doubtless been produced.

The efficiency of these nitragin preparations upon soils where the organisms are absent has been repeatedly demonstrated in various parts of Europe, striking examples of which were seen by one of us in the summer of 1898, upon the peat (hoch Moor) experimental grounds of the Bremen Experiment Station, at Hude, in North Germany.

TREATMENT OF SEED OATS TO PREVENT SMUT.

J. A. TILLINGHAST.

This experiment was begun in 1895, and continued for three years. The work of 1895 and 1896 was under the direction and charge of C. O. Flagg and G. M. Tucker; that of 1897, of C. O. Flagg and J. A. Tillinghast.

Although considerable work has been done and published on this subject, yet we find comparatively few farmers who, in actual farm practice, treat their seed for the prevention of smut.

It is hoped that the results of this experiment will call attention to the decided benefits arising from the use of treated seed, and tend to make the practice more universal throughout the State.

The loose smut of oats (*Ustilago avenae*), like all smuts of cereals, is caused by minute parasitic fungi, of which the spores form the black, dusty matter which is found in place of the kernels or the entire head.

These minute spores are blown about by the wind and often adhere to the kernels and remain upon them until planted. Then, as the grain germinates, the spores also germinate, sending delicate threads into the young plants, and follow the growth of the plant until the head forms. A mass of spores is then developed instead of kernels.

Another form of this smut (*Ustilago avenae levis*) is much harder to detect, as it only destroys the kernel, leaving the outer chaff unaffected.

Fields of oats should be examined at or soon after the time of

blossoming, as at the time of harvesting many of the smutted heads are entirely bare and would not be noticed.

The need of farmers being able to combat this disease in evidenced by the fact that it is estimated to cause an annual loss in the United States of more than $18,000,000.*

The Jensen hot water treatment of seed oats has proved very effective in preventing this disease, and is simple and easily available to every farmer.

Provide two large vessels, and an accurate thermometer. One vessel should contain warm water at 110° to 120° F. and the other hot water at 132° to 133° F. The latter must be kept at that temperature, adding cold water if it rises above 133°, and hot water if it falls below 132°. If steam is available it is an excellent means of keeping the water at the proper temperature.

Dip the seed, loosely enclosed in a coarse sack, into the warm water, allowing it to remain until thoroughly wet and warm, then immerse it in the hot water, agitating it thoroughly, and let it remain ten minutes. Take out, and, if not to be sown at once, spread thinly to dry.

To test the effectiveness of this method thirty-nine plots, each six by eight feet, were fertilized alike and sown broadcast, using two ounces of seed per plot. Thirteen varieties of oats were used in the experiment. Each variety occupied three plots, one sown with treated seed, the other two with untreated seed.

Oats were sown April 26th, and harvested August 8th. Table I gives a comparison of yields of each variety from treated and untreated seed, also the number of smutted heads grown from the two ounces of seed, of each variety.

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* Farmers' Bulletin, No. 75, U. S. Department of Agriculture, p. 10.

TABLE I.

Showing Gain in Grain and Straw by Jensen Treatment, 1895.

Plot Number.	Variety.		Comparison of Yields. Total weight of straw and grain.	Comparison of Yields. — = 5 lbs.	Number of smutted heads from 2 ounces of seed sown.
			lbs.		
1	Race Horse	Treated	6.7		0
		Untreated	5.0		1
2	Market Seed*	Treated	7.8		0
		Untreated	6.9		7
3	Pride of Michigan	Treated	7.6		0
		Untreated	6.4		9
4	Market Seed†	Treated	7.8		0
		Untreated	6.2		3
5	Market Seed‡	Treated	8.0		0
		Untreated	6.6		6
6	Market Seed§	Treated	8.8		0
		Untreated	7.4		16
7	Mammoth Cluster	Treated	8.5		0
		Untreated	8.1		5
8	German White	Treated	8.9		0
		Untreated	7.7		1
9	Early Swede	Treated	9.3		0
		Untreated	7.4		1
10	Great White Maine	Treated	9.1		0
		Untreated	7.3		2
11	White Russian	Treated	9.3		0
		Untreated	7.5		2
12	Early Golden Prolific	Treated	8.9		0
		Untreated	8.4		10
13	Probiester	Treated	9.4		0
		Untreated	8.7		0

*Obtained of J. H. & J. B. Sweet, Providence. †Obtained of W. E Barrett & Co., Providence. ‡Obtained of J. C. Tucker, Jr., Wakefield. §Obtained of E. P. & S. L. Tucker, West Kingston.

Continuation of Experiment in 1896.

The trial this season was with twelve varieties, as follows:

No. 1. Western grown, from E. P. & S. L. Tucker, West Kingston, R. I.

No. 2. Western grown, from J. C. Tucker, Jr., Wakefield, R. I.

No. 3. White Maine, from H. A. Dreer, Philadelphia, Pa.

No. 4. Lincoln, from Farmers' Seed Co., Faribault, Minn.

No. 5. Lincoln, from L. L. Olds, Clinton, Wis.

No. 6. Lincoln, from Johnson & Stokes, Philadelphia, Pa.

No. 7. Clydesdale, from Peter Henderson & Co., New York.

No. 8. New White Maine, from Johnson & Stokes, Philadelphia, Pa.

No. 9. White Maine, from Wm. H. Maule, Philadelphia, Pa.

No. 10. Lincoln, from Wm. H. Maule, Philadelphia, Pa.

No. 11. Danish Island, from W. Atlee Burpee & Co., Philadelphia, Pa.

No. 12. Western grown, from W. E. Barrett & Co., Providence, R. I. Two ounces of seed were sown broadcast on each plot (six by eight feet), as last season.

Each variety was sown on three plots, one with treated seed, the other two with untreated seed.

The treatment was in water at 135° F. for five minutes.

The oats were sown May 7th, and on July 3d the average height of plants on each plot was taken (see Table II). At this time it was noted that the oats upon all the treated plots were darker in color than those upon the untreated ones.

TABLE II.

Showing the Result in Yield of Oats Due to the Jensen Treatment, 1896.

Number of Variety.	Average Height July 3d.		Total Weight.		Weight of Grain.		Weight of Straw.		Gain (+) Loss (—) of Grain by Treatment.	Gain (+) Loss (—) of Straw by Treatment.	Per cent. of Grain.		Per cent. of Straw.		Gain (+) Loss (—) Per cent. of Grain by Treatment.	Gain (+) Loss (—) Per cent. of Straw by Treatment.
	Treated.	Untreated.	Treated.	Untreated.	Treated.	Untreated.	Treated.	Untreated.	Pounds.	Pounds.	Treated.	Untreated.	Treated.	Untreated.		
	ft. in.	ft. in.														
1	3—0	2—8	15.75	11.25	2.65	2.90	13.10	8.35	—0.25	+4.75	16.83	25.78	83.18	74.22	—8.62	+56.89
2	2—8	2—6	15.25	11.50	2.35	2.25	12.90	8.75	+0.10	+4.15	15.41	20.45	84.59	79.55	+4.44	+47.43
3	3—1	2—8	14.75	10.50	2.70	2.10	12.05	8.40	+0.60	+3.65	18.31	20.00	81.69	80.00	+28.57	+43.45
4	3—0*	2—10	14.75	12.50	2.85	2.40	11.90	10.10	+0.45	+1.80	19.32	19.20	80.68	80.80	+18.75	+17.82
5	3—0	2—9	17.00	11.25	2.90	2.40	14.10	8.85	+0.50	+5.25	17.06	21.33	82.94	78.67	+23.33	+59.32
6	3—3	2—8	16.25	13.25	2.95	2.50	13.30	10.75	+0.45	+2.55	18.15	18.87	81.84	81.13	+18.00	+23.72
7	3—0	2—9	15.75	12.25	2.75	2.80	13.00	9.45	—0.05	+3.55	17.46	22.85	82.53	77.15	—1.78	+37.56
8	2—11	2—10	14.00	12.50	3.05	3.00	10.95	9.50	+0.05	+1.45	21.79	24.00	78.21	76.00	+1.67	+15.26
9	2—10*	2—9	15.25	12.75	3.25	2.35	12.00	10.40	+0.90	+1.60	21.31	18.43	78.69	81.57	+38.29	+15.38
10	3—0	2—6	16.50	12.50	3.80	2.70	12.70	9.80	+1.10	+2.90	23.03	21.60	76.97	78.40	+40.74	+29.49
11	3—0	2—6	15.00	10.75	3.10	2.60	11.90	8.15	+0.50	+3.75	20.67	24.18	79.33	75.82	+19.23	+46.01
12	2—11	2—8	11.50	12.00	3.00	2.50	8.50	9.50	+0.50	—1.00	26.09	20.83	73.91	79.17	+20.00	—10.53

* Contained one smutted plant.

On July 15th and 20th the plants on one untreated plot of each variety were pulled, and the healthy and smutted plants counted. (See Table III.)

The oats on the remaining plots were harvested on August 1st; threshed August 5th, and weights of grain and straw from the treated and untreated plots taken. These weights are given in Table II, as is also the gain or loss of grain and straw of each variety, from the treated as compared with the untreated seed.

TABLE III.

Showing the Amount of Smut on Oats Grown from Treated and Untreated Seed. 1896.

Number of Variety.	Average Height of Plants.		Total Number of Plants.	Number of Healthy Plants.	Number of Smutted Plants.	Per cent. of Smutted Plants.	Number of Smutted Plants.	Per cent. of Smutted Plants.
	Treated.	Untreated.	Untreated.	Untreated.	Untreated.	Untreated.	Treated.	Treated.
	ft. in.	ft. in.						
1	3–0	2–8	1,656	1,652	4	0.24	0	0.00
2	2–8	2–6	1,569	1,548	21	1.34	0	0.00
3	3–1	2–7	1,759	1,724	35	1.98	0	0.00
4*	3–0	2–9	1,636	1,479	157	9.59	1	0.0006
5	3–0	3–0	1,637	1,603	34	2.08	0	0.00
6	3–3	2–8	1,968	1,912	56	2.84	0	0.00
7	3–0	2–8	1,173	1,167	6	0.51	0	0.00
8	2–11	2–7	1,598	1,535	63	3.94	0	0.00
9	2–10	2–8	1,559	1,491	68	4.36	0	0.00
10	3–0	2–6	1,727	1,527	200	11.57	0	0.00
11	3–0	2–4	1,547	1,489	58	3.75	0	0.00
12	2–11	2–6	1,712	1,625	87	5.08	0	0.00
Average	2–11.7	2–7	1,628.42	1,562.67	65.75	4.04	0	0.00

* Only one smutted plant was found on the Jensen treated plots.

Continuation of Experiment in 1897.

Thirteen varieties of oats were used in the experiment, and in connection with the Jensen treatment a trial was also made of Ceres Pulver, a substance advertised as a smut preventive, and which is, according to the analysis by Hollrung, and other German investigators, crude potassium sulfid, sold under another name at an advanced price.

The oats were accurately weighed in two-ounce lots before treating. Those for the Jensen treatment were immersed in water at 115° F. until thoroughly wet and warm, then in water at 132.5° F. for ten minutes, great care being taken not to allow the temperature to vary. They were then thinly spread to dry.

For the Ceres Pulver treatment, the oats were put in small heaps, the Ceres Pulver dissolved in water, as per directions on the package, and sprinkled over them, turning and mixing them thoroughly that each seed might become wet with the liquid. They were then thinly spread to dry.

Four plots, each six by eight feet, were sown with each variety, using two ounces of seed on each plot. Of these plots, two were sown with untreated seed and one each with seed prepared by the Jensen and Ceres Pulver method.

The oats were sown on April 28th, and showed no decided difference in germination or growth, except a tendency of the treated seed to produce slightly taller plants than the untreated.

On August 3d and 5th, the oats from untreated seed on one row of plots, and also on the plots where the seed was treated with Ceres Pulver were pulled, and the healthy and smutted plants counted. (See Table IV.)

TABLE IV.

Showing Amount of Smut from Untreated Seed and from that Treated with Ceres Pulver.

NAME OF VARIETY.	UNTREATED. Total Number of Plants.	CERES PULVER. Total Number of Plants.	UNTREATED. Number of Healthy Plants.	CERES PULVER. Number of Healthy Plants.	UNTREATED. Number of Smutted Plants.	CERES PULVER. Number of Smutted Plants.	UNTREATED. Per cent. of Smutted Plants.	CERES PULVER. Per cent. of Smutted Plants.
Probiester	1,977	2,537	1,879	2,474	98	63	4.95	2.48
Mexican Clydesdale	‡	1,616	‡	1,615	0	1	0.00	0.06
Gray Winter	2,306	‡	2,301	‡	5	0	0.21	0.00
Lincoln	2,015	2,024	1,980	2,008	35	16	1.73	0.79
* H. Aldrich	1,801	1,788	1,800	1,787	1	1	0.05	0.05
Mortgage Lifter	1,578	1,506	1,521	1,398	57	108	3.61	7.17
Welcome	1,834	1,946	1,700	1,875	134	71	7.30	3.64
Golden Giant Side	2,134	1,977	2,118	1,975	16	2	0.74	0.10
Pride of Michigan	1,891	1,808	1,850	1,805	41	3	2.16	0.16
* F. E. Marchant	1,852	1,486	1,850	1,485	2	1	0.10	0.06
W. E. Barrett & Co	1,744	1,802	1.705	1,800	39	2	2.23	0.11
‡ R. I. Experiment Station	‡	‡	‡	‡	0	0	0.00	0.00
* † J. H. Harris	1,580	1,570	1,565	1,568	15	2	0.94	0.12

* Native variety. † Mixed with wild oats (*Avena fatua*).
‡ No smut being found, plants were not counted.

It should be noted that, although an exactly equal weight of seed was sown upon each plot, the number of plants produced varied considerably, and this should be taken into consideration when comparing the yields.

No smutted plants could be found where the Jensen treatment was used, and these, with those from the remaining plots where untreated seed was used, were harvested in the usual manner.

On August 20th the oats were threshed and weights of grain and straw taken. (See Table V.)

TABLE V.

Showing Yields of Oats and Straw from Untreated Seed, and from that Receiving Jensen and Ceres Pulver Treatment, 1897.

NAME OF VARIETY.	UNTREATED.			JENSEN.			CERES PULVER.		
	Total. lbs.	Oats. lbs.	Straw. lbs.	Total. lbs.	Oats. lbs.	Straw. lbs.	Total. lbs.	Oats. lbs.	Straw. lbs.
Probiester	8.00	1.25	6.75	7.75	1.50	6.25	10.25	2.00	8.25
Mexican Clydesdale	7.00	2.25	4.75	6.00	1.75	4.25	8.50	2.50	6.00
Gray Winter	6.25	0.50	5.75	6.50	0.75	5.75	6.75	0.75	6.00
Lincoln	7.75	1.75	6.00	9.00	2.00	7.00	8.25	2.50	5.75
* H. Aldrich	7.25	2.50	4.75	7.25	2.25	5.00	8.25	2.50	5.75
Mortgage Lifter	6.50	2.00	4.50	7.50	1.75	5.75	7.50	1.25	6.25
Welcome	7.50	2.00	5.50	7.75	1.75	6.00	9.00	1.75	7.25
Golden Giant Side	7.50	1.00	6.50	8.50	1.25	7.25	7.50	1.50	6.00
Pride of Michigan	7.75	1.00	6.75	8.50	0.75	7.75	7.50	1.00	6.50
* F. E. Marchant	8.75	1.75	7.00	8.25	1.50	6.75	9.00	2.00	7.00
W. E. Barrett & Co	8.50	1.00	7.50	8.00	1.25	6.75	9.00	1.00	8.00
R. I. Experiment Station.	9.25	1.25	8.00	9.00	1.25	7.75	10.00	1.50	8.50
* † J. H. Harris	6.75	1.50	5.25	6.50	1.00	5.50	8.50	2.00	6.50

* Native variety. † Mixed with wild oats (*Avena fatua*).

TABLE VI.

Showing Results in Yield of Oats from Seed Receiving Jensen and Ceres Pulver Treatment, Compared with the Yield from Untreated Seed. 1897.

Name of Variety.	Gain (+) loss (—) in lbs. of Grain from Treated Seed.		Gain (+) loss (—) in lbs. of Straw from Treated Seed.		Per Cent. of Grain.			Per Cent. of Straw.			Gain (+) loss (—) Per Cent. of Grain from Treated Seed.		Gain (+) loss (—) Per Cent. of Straw from Treated Seed.	
	Jensen.	Ceres Pulver.	Jensen.	Ceres Pulver.	Untreated.	Jensen.	Ceres Pulver.	Untreated.	Jensen.	Ceres Pulver.	Jensen.	Ceres Pulver.	Jensen.	Ceres Pulver.
Probiester	+0.25	+0.75	—0.50	+1.50	15.63	19.35	19.51	84.37	80.65	80.49	+20.00	+60.00	—7.40	+22.22
Mexican Clydesdale	—0.50	+0.25	—0.50	—1.25	32.14	29.17	29.41	67.86	70.83	70.59	—22.22	+11.11	—10.53	+26.31
Gray Winter	+0.25	+0.25	0.00	+0.25	8.00	11.54	11.11	92.00	88.46	88.89	+50.00	+50.00	00.00	+4.34
Lincoln	+0.25	+0.75	+1.00	—0.25	22.59	22.22	30.30	77.41	77.78	69.70	+14.28	+42.85	+16.16	—4.17
H. Aldrich	—0.25	0.00	+0.25	+1.00	34.48	31.03	30.30	65.52	68.97	69.70	—10.00	00.00	+5.26	+21.05
Mortgage Lifter	—0.25	—0.75	+1.25	+1.75	30.76	23.33	16.66	69.24	76.67	83.34	—12.50	—37.50	+27.77	+38.88
Welcome	—0.25	—0.25	+0.50	+1.75	26.66	22.58	19.44	73.34	77.42	80.56	—12.50	—12.50	+9.09	+31.81
Golden Giant Side	+0.25	+0.50	+0.75	—0.50	13.33	14.70	20.00	86.67	85.30	80.00	+25.00	+50.00	+11.53	—7.69
Pride of Michigan	—0.25	0.00	+1.00	—0.25	12.90	8.82	13.33	87.10	91.18	86.67	—25.00	00.00	+14.81	—3.70
F. E. Marchant	—0.25	+0.25	—0.25	0.00	20.00	18.18	22.22	80.00	81.82	77.78	—14.28	+14.28	—3.57	00.00
W. E. Barrett & Co.	+0.25	0.00	—0.75	+0.50	11.76	15.63	11.11	88.24	84.37	88.89	+25.00	00.00	—10.00	+6.66
R. I. Experiment Station	0.00	+0.25	—0.25	+0.50	13.51	13.88	15.00	86.49	86.12	85.00	00.00	+20.00	—3.13	+6.25
J. H. Harris	—0.50	+0.50	+0.25	+1.25	22.22	15.38	23.53	77.78	84.62	76.47	—33.33	+33.33	+4.76	+23.80

SUMMARY.

The result of the experiment, as a whole, shows the Jensen treatment to be a thorougly effective preventive of smut, and also shows its tendency to increase the yield of both grain and straw. Only one smutted plant was found on the treated plots in 1896, and none in 1895 or 1897.

In 1895 there was a decided gain in the total weight of grain and straw from the treated seed. In 1896 the average gain of all varieties by treatment was, of grain 17.3 per cent., and of straw 31.8 per cent. In 1897 there was an average loss of .34 per cent. of grain, and an average gain of 4.21 per cent of straw, five of the varieties showing a gain in grain, and eight varieties a gain in straw, by the Jensen treatment. The Ceres Pulver treatment, while not entirely effective in destroying the smut spores, increased the average yield of both grain and straw, and reduced quite largely the per cent. of smut in most cases.

The average gain of all varieties was 17.81 per cent. of grain, and 12.75 per cent. of straw.

This treatment would probably prove much more effective if used as advised in Farmers' Bulletin, No. 75, Department of Agriculture, page 18. The method given is as follows:

Soak the seed for twenty-four hours in a solution of 1½ pounds of potassium sulfid to twenty-five gallons of water, or for two hours in a solution of eight pounds to fifty gallons of water.

It would seem that this method would allow the liquid to fill every interstice and kill the smut spores much more certainly than by simply sprinkling and turning the seed.

It is interesting to note the considerable increase of both grain and straw from nearly all of the plots where the seed was treated with Ceres Pulver. This may perhaps be in some considerable degree attributed, aside from its use in preventing the smut, to a manurial effect of the sulfid of potassium, which adheres to some extent to the seed so treated, and being at hand for immediate use gives the young plants a slight advantage in their early stage of growth.

Notes as to Growth and Yield of the Varieties of Oats Used in the Trial, Grown from Untreated Seed.

On August 2d it was noted that the early varieties were less affected by rust than the late ones. The earliest, largest yielding variety, and also that least affected by rust, was grown from seed obtained from Mr. Henry Aldrich, Woonsocket, R. I., which had been grown in that vicinity for a long term of years.

Seed of another native variety was received from John Harris, Greene, R. I., and had been grown in that vicinity for about forty years. This variety, however, was found quite badly infested with wild oats (*Avena fatua*).

The following table gives the yields and other data, which it is well to remember are, as in any trial of varieties, largely dependent upon local soil and climatic conditions. The oats were sown on April 28th, and harvested on August 5th.

Table Giving Yield of Varieties of Oats Grown from Untreated Seed. 1897.

Name of Variety.	Mature.	Yield per Acre.		Rust.	Lodged.
		Oats. Bushels.	Straw. Tons.		
H. Aldrich	Early.	70.9	2.2	A trace.	Very slightly.
Mexican Clydesdale	Medium.	63.8	2.2	Some.	Somewhat.
Welcome	Medium.	56.7	2.5	Some.	Somewhat.
Mortgage Lifter	Early.	56.7	2.0	A trace.	Badly.
F. E. Marchant	Medium.	49.9	3.2	Some.	Somewhat.
Lincoln	Early.	49.6	2.7	Some.	Slightly.
J. H. Harris	Medium.	42.5	2.4	Some.	Somewhat.
R. I. Experiment Station	Medium.	35.5	3.6	Some.	Badly.
Probiester	Medium.	35.5	3.1	Considerable.	Slightly.
W. E. Barrett & Co	Late.	28.4	3.4	Considerable.	Somewhat.
Golden Giant Side	Late.	28.4	3.0	Considerable.	None.
Pride of Michigan	Late.	28.4	3.1	Considerable.	None.
Gray Winter	Late.	14.2	2.6	Considerable.	Very slightly.

ON A POSSIBLE ERROR IN THE DETERMINATION OF NITROGEN IN NITRATES DUE TO IMPURITIES IN REDUCED IRON.

B. L. HARTWELL AND H. J. WHEELER.

Reduced iron is employed in two of the methods for the determination of nitrogen in nitrates, which are in use by the Association of Official Agricultural Chemists. Recently in making blank determinations with a new lot of so-called chemically pure reduced iron, it was found that by the modified Ulsch method much less ammonia was required for neutralizing the acid than in the case of blank tests formerly made. The error from this cause in determinations, involving half a gram of commercial sodium nitrate, would amount to from .30 to .35 of a per cent. By direct distillation, without first allowing the iron to dissolve in the acid, no difficulty was experienced. The reduced iron bore the label of one of the leading manufacturers of chemicals in Germany, and was ordered through a prominent and reliable firm in this country.

Since these tests were made an account of a similar observation by L. Brandt* has been noticed. Brandt found in a similar manner an error equivalent to .8 of a per cent., assuming half a gram of nitrate to be employed in a single test. As in our own case, he assured himself that the error was not due to any of the other reagents, nor to the apparatus employed, and also found that the error did not appear unless the iron was dissolved in the

* Chemiker Zeit. 23 (1899), p. 22.

acid before the distillation. From various tests made by Brandt he concluded that the impurity in the iron was in the form of some organic nitrogen compound, which probably gained access to it subsequent to its reduction by hydrogen. Further experiments showed that the impurity could be removed by heating the iron in a current of hydrogen, though the accomplishment of the object was impossible by extraction with water, alcohol, or ether. Brandt very properly closes the account of his observations by stating that the experience further indicates the propriety of never placing implicit confidence in chemicals claimed to be chemically pure, but to test everything before using it.

In view of the recent extension of the use of the modified Ulsch method in the laboratories of this country, it seemed important that our own analysts should be put on their guard as to the possible character of the reduced iron sold as chemically pure.

POULTRY DIVISION.

A. A. BRIGHAM.

A brief outline of the plans for this division, and a statement of several matters relating to the same, are given in the report of the director, who for several months has had special charge of the work in this line. Attention is also called to "Notes on Roup in Fowls," by Mr. John Barlow, in the Biological Division of this report.

NEGLIGENCE IN BREEDING.

One matter already mentioned needs to be strongly emphasized. This is the frequent neglect of the fundamental principles of breeding in the management of poultry. Carelessness in this respect has doubtless paved the way for destructive diseases, like roup, blackhead, etc., to work their disastrous results. The practical poultry breeder of to-day must seek to know, as thoroughly as possible, the workings of heredity, atavism, prepotency, variation, and correlation, in their relations to the development of fowls.

Further, the requisites in successful breeding of poultry may be summarized as follows:

First. Health and good constitution.

Second. Good pedigree (a long line of good ancestors).

Third. Good conformation and color.

Fourth. Good temper and docile disposition.

Fifth. Favorable environment and management.

Not to dwell at length on this subject, let us consider briefly one or two illustrations of certain lines of action. A study of the turkey raising industry of Rhode Island, in connection with the development of that dread disease, the "blackhead," brings out the fact that it has been quite a common practice in some sections where turkeys were raised in large numbers to sell all of the early hatched and best developed birds for the Thanksgiving trade. Later, when the question of raising the next year's supply came up, such birds as were "left over" from the previous autumn were used to breed from. These were usually closely related, and often the male used to head the flock was a late hatched, inferior bird. After this plan had been followed a few years the breeding stock began to "run out." Size, constitution, vigor, and health all became reduced. The death rate increased, and then came the blackhead disease to complete the ruin of the weakened flocks. Spasmodic attempts to turn the tide, by purchasing vigorous, healthy males from a distance to breed with the debilitated flocks, have amounted to little. Moreover, the turkey breeding grounds of Rhode Island have apparently become thoroughly infected with the protozoön, which causes the disease, in some stage or other of its life cycle. Good constitution and health, the first requisites in successful poultry breeding, have been neglected, while the principles of heredity and variation have kept working on, but, unfortunately, not in the direction of plump birds or of plump pocket-books for Thanksgiving time in city or country. More than two centuries ago farmers had developed stock breeding to such an extent that they recognized two closely related rules concisely expressed in the axioms "Like begets like," and "Breed from the best." Those turkey breeders who have neglected these rules are, unfortunately, several centuries behind these wise old stockmen.

Another point is worth mentioning. It is a very prevalent belief among farmers who raise common fowls that "fresh blood," in the form of a male, from the yard of some other poultryman, should every year be introduced to keep up the vigor of the

flock. Where careless breeding is the rule this is sometimes necessary to keep the flock in existence, but if, as is often the case, the new bird is chosen each time from a different flock, and perhaps from a different breed, then the result may possibly be increased vigor, and not much else. In following this course the poultry breeder disregards the second requisite—good pedigree (a long line of good ancestors)—and breaks the power of prepotency, which is increased immeasurably by judicious "inbreeding," and particularly by "line breeding," by means of which some of our wise Rhode Island poultrymen have systematically developed in their birds marvelous quality without neglecting the essential vigor and strength of constitution.

The fanciers delight in the development of color, and in this line wonderful results have been attained. There is one thing that needs emphasizing, and that is, if permanently valuable results in color of plumage are to be secured and maintained, one must work along with nature, and not against her. If our experimentation is to be of any real or permanent value, this idea must be kept in mind. The breeder may leave the principle of correlation out of calculation, but the birds will not. The whole bird and all its parts must be considered, hence a standard of a breed should give proper weight to all related characteristics. A false standard, or a lack of good judgment, may temporarily give to some "fancy fad" in color undue importance and cause a breeder to neglect conformation, size, vigor, and breeding quality. Some breeders of Barred Plymouth Rocks in their inordinate desire for "barring to the skin" are securing their object in the under color of the plumage, but with the accompaniment of a smoky outer plumage and numerous black feathers and in some cases loss of size and conformation. Does it pay to ruin a good breed, or even its surface color, for the sake of extending the barring to the fluffy, hidden parts of the feathers? Is enough gained by the practice of "double mating," so-called, to pay for the trouble? If there are Plymouth Rock breeders who are sufficiently interested in this matter to coöperate in an experiment to determine what can

be done in developing the Barred Rocks without double matings, this Station would like to hear from them.

Again, what will be the result of breeding the black out of the tails of the buff varieties? Will it not be a faded, characterless, yellow body color, with loss of vigor as well as beauty? And then there is the rage for the "chalky white" in the white breeds, which can be secured, but is there sufficient gain to warrant the breeder's keeping his fowls out of the sunshine, which, although it develops the yellow surface tinge on the plumage of these birds, helps their health, increases their vigor, and is destructive to the germs of tuberculosis and other diseases?

It is in the requisite last named in the list, the favorable environment and management, that the breeder has the greatest opportunity for influencing the development of his fowls. Heredity is in these times coming to be considered by some biologists as a less important factor than environment in developing the characters of animals. When more of our poultrymen have come to be strongly grounded in the principles of breeding, probably the most helpful investigation and experimentation which can be undertaken will be in relation to some of the phases of environment. Location, food, shelter, and all the conditions that surround the life of the bird, have their influence.

One point further needs special emphasis here. The birds have lungs for the purpose of breathing in the air to gain its oxygen. These lungs in their size, their coatings, and their rapidity of respiration, are adapted to an atmosphere of pure air containing in its bulk about twenty-one parts of oxygen to seventy-nine parts of nitrogen. This is essentially the composition of common pure air. If these proportions are materially changed, or if other gases are introduced, disorder and usually disease results.

VENTILATION.

Pure air being essential to the healthy life of poultry, it becomes necessary to provide some efficient means of supplying the same constantly to the fowls. In attempting to ameliorate the

conditions of our severe climate by providing shelter for the fowls, we must not cut off the supply of oxygen, or allow it to be supplanted by ammonia, carbonic acid or other useless or noxious gases arising from the fowls, their excrement or surroundings. In this line we have during the past year undertaken experimentation in brooding having for its definite object the securing "without injurious draughts, of a continuous and sufficient supply of fresh, pure air, delivered to the chickens throughout the day and night at a constant and suitable temperature." Through the kind efforts of Mr. Mark Dean, engineer, of Boston, Mass., a gravity apparatus, designed by himself at our request, was installed in one of the brooder houses of our poultry plant. The plan includes the taking of fresh air from outside the building, conducting it to a hot water radiator, where, passing between the hot pipes, it is warmed, and then rises through an automatic mixing damper to the top of the brooder box. A thermostat, placed in the conduit which carries the air to the brooder box, connected with the mixing damper, being set for a certain temperature, causes the damper to close more or less and let in such an amount of warm and cold air as when mixed will give the right temperature. The fresh, pure, moving air of suitable temperature is constantly being supplied to the top of the brooder box, and sifts down through a cloth diaphragm into a chamber containing the chickens, thence passing out of the box in front where the chicks may at will pass in or out.

The preliminary tests of this apparatus indicate that we are on the right track. After further and most thorough testing of this and several other plans of heating and ventilating brooders, a complete and descriptive report of the results will be published.

Enough has now been written, it is hoped, to indicate that poultry culture to succeed must be conducted along definite lines, based upon the laws of nature and of life, and that the poultryman should have as complete an understanding as possible of these laws. In order that this Station may be truly helpful our work must also have the same basis. That there may be no mis-

take as to the object of this statement of the situation, we would say in closing that it is not alone the fancier, but likewise the practical poultry keeper, who must seek to become well grounded in the principles and natural laws involved in the breeding and keeping of poultry. Both the utility and the beauty of fowls are developed most successfully by the poultryman who best understands his birds, is most familiar with the factors to be used, and studies most closely the relations of cause and effect. This statement applies to the practical farmer and the poultry keeper who seeks the most profitable results in eggs and dressed fowls for market. Neglect of first principles will defeat his object. With this idea in view, we invite the hearty coöperation of every poultryman in the State, or out of it, for that matter, in the development of both our experimental and educational work for the advancement of poultry culture.

METEOROLOGICAL REPORT.

NATHANIEL HELME.

The usual routine duties of weather observations, three times each day, the sending of crop reports during the growing season, and of reports of depths of snow, once each week during the winter, to the Director of the Weather Service in Boston, the publishing each month, in the *Journal* and *Bulletin*, of the weather conditions, and the daily forecasts of the weather in the *Bulletin* have been performed by the department.

Commencing January 1, 1898, there was a change made in the time of displaying the weather signals, so that they now give the forecast of the weather for the day following that on which they are displayed. This change, I think, has been appreciated.

Summary for 1898.

Maximum temperature....................	95°	July 3.
Minimum temperature....................	—4°	December 14.
Highest monthly mean	71°	August.
Lowest monthly mean........................	27.9°	January.
Highest daily mean	80°	September 1.
Lowest daily mean.........................	6°	February 2.
Mean temperature of the year.............	48.8°.	

Precipitation.

Total for the year (rain and melted snow).	72.21 inches.		
Largest total for one month............	12.05	"	October.
Least total for one month..............	.77	"	June.

Greatest precipitation in 24 consecutive hours	5.50	inches.	July 13.
Total snow-fall for the year	$59\frac{3}{4}$	"	
Largest total for one month	20	"	November.
Least total for one month	$1\frac{3}{4}$	"	December.

Weather.

Number of clear days in the year	110
Number of partly cloudy days	114
Number of cloudy days	141
Number of days with precipitation of .01 inch or more	131

Prevailing Winds.

N. E., 1 month; E., 1 month; S. W., 5 months; W., 5 months.

Summary, 1890 to 1898, Inclusive.

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Maximum temperature	91°	94°	92°	92°	93°	95°	93°	90°	95
Minimum temperature	8°	5°	—1°	—6°	—9°	—7°	—11°	1°	—4
Mean temperature	48.3°	49.4°	47.8°	46.5°	48.6°	48.2°	47.7°	48.3°	48.8
Total precipitation (inches)	59.25	49.88	42.58	57.33	48.19	49.28	49.87	54.25	72.21
Number of clear days	99	116	147	126	110	128	131	129	110
Number of fair days	143	154	116	130	130	114	112	126	114
Number of cloudy days	123	95	103	109	125	123	123	110	141
Number of days with precipitation of .01 inch or more	120	83	89	131	114	108	109	128	131

Average mean temperature, 48.2°.

Average precipitation, 53.65 inches.

The mean temperature of January was very near, and the precipitation above, the average. The ground was bare of snow until the 26th. On the 31st commenced one of the heaviest snow-storms known here for nearly thirty years. The damage done by the storm was very considerable.

On the first day of February the snow-storm, commencing the day before, ended, the average depth being from 15 inches to 18 inches. On the 20th and 21st occurred a very heavy rain-fall, the total for the two days being 6.69 inches. This storm caused a freshet, and a great amount of damage was done, highways being badly washed out, and a number of small bridges carried away. The lowest temperature of the winter (—2°) was recorded this month. Thunder and lightning were observed during the rain-storm of the 21st. The total precipitation was nearly twice the average of the month for ten years.

There were no severe storms in March, and there was also an absence of the high winds which generally prevail during this month. The latter part of the month was quite spring-like, and considerable farm work had been done in the way of preparing the ground and sowing of oats and grass seed.

April was a cloudy and wet month. The rain-fall was above the average, and more than half of the month was cloudy. Five inches of snow fell on the 5th of the month, and ice formed as late as the 27th.

May, like April, was a wet and cloudy month. The rain-falls were frequent, and most of them very heavy. The large amount of water in the ground caused the flooding of many cellars, and for the same reason, at the end of the month, a number of gardens had not been ploughed. An inch of snow fell on the night of the 8th, and some of it remained in the shade of buildings for a day or two afterwards. The rain-fall was nearly twice the average for the month.

In contrast with April and May, June was a dry month. The total rain-fall was less than one inch, and about one-fifth the average for the month. White frost was observed in several places on the morning of the 16th, one person reporting it heavy enough to injure tender plants. At the close of the month haying was commenced with prospects of a good crop.

The first part of July was very hot. The maximum temperature of the year, 95°, was recorded on the 3d. On the 13th there was heavy rain, the total for the day being 5.5 inches. The temperature and rain-fall of the month were both above the average.

August weather was characterized by a high percentage of humidity, and it was the hottest and wettest August during the eleven years that the record has been kept here. Heavy rain fell on the 10th and 11th, the total for the two days being 4.14 inches.

September was generally warm, with plenty of sunshine, and weather very favorable for the harvesting of crops. The mean temperature was 2° above, and the rain-fall 2 inches less than the average for the past ten years.

The rain-falls for October were generally heavy, there being but one or two exceptions, and the total was the largest for any single month during the eleven years that the record has been kept here. The mean temperature was above the average for the month, and there were many fine days, making altogether an ideal autumn month.

The first part of November was mild and pleasant. On the 26th and the 27th occurred one of the heaviest storms of snow ever known here, and somewhat unprecedented for November. The gale accompanying the storm did a large amount of damage. Travel was much impeded by the drifting of the snow on the highways. The total snowfall for the month was 20 inches. The temperature was below and the precipitation above the average for the month.

December registered the lowest temperature of the year, —4°, on the 14th. The precipitation was not very heavy, the total being 2.71 inches, and the snow-fall being $1\frac{3}{4}$ inches. There were no severe storms during the month, which closed with mild weather, though the temperature began to fall quite rapidly on the night of the 31st.

The first snow of the autumn fell November 26th, and the last of the spring, May 8th.

The first autumn frost formed September 9th, and the last spring frost, June 16th.

The following tables give the principal features of the weather for each day of each month, and the maximum and minimum temperature and the prevailing wind, while the supplementary table shows the number of clear, partly cloudy, cloudy, and rainy days for each month.

WEATHER SUMMARY FOR JANUARY, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	35°	10°	22.5°	.10	W.	Fair.
2	22	4	13	....	W.	Clear.
3	31	9	20	....	W.	Fair.
4	31	3	17	.18	N.E.	Cloudy.
5	38	22	31	....	W.	Clear.
6	42	24	33	....	S.E.	Cloudy.
7	44	29	36.5	.43	W.	Fair.
8	44	27	35.5	....	S.W.	Fair.
9	37	27	32	....	W.	Fair.
10	43	25	34	....	S.W.	Clear.
11	40	28	34	....	Variable.	Cloudy.
12	47	34	40.5	.14	S.E.	Cloudy.
13	54	28	41	....	W.	Fair.
14	33	22	27.5	....	W.	Cloudy.
15	38	27	32.5	.65	S.E.	Cloudy.
16	38	26	32	....	W.	Fair.
17	26	15	20.5	....	W.	Clear.
18	35	12	23.5	....	W.	Fair.
19	37	19	28	....	E.	Fair.
20	52	28	40	1.31	Variable.	Cloudy.
21	45	31	38	....	W.	Clear.
22	37	27	32	.02	E.	Cloudy.
23	51	31	41	1.92	S.W.	Fair.
24	37	24	30.5	....	N.W.	Clear.
25	34	18	26	.05	S.E.	Fair.
26	35	28	31.5	.33	N.	Fair.
27	28	15	21.5	....	W.	Fair.
28	21	10	15.5	....	W.	Fair.
29	20	5	12.5	....	Variable.	Cloudy.
30	15	0	7.5	....	N.	Clear.
31	31	3	17	1.20	N.E.	Cloudy.
Sum.......	1,121	611	866	6.33	....	....
Mean......	36.1	19.7	27.9	....	....	....

Maximum temperature........54°. Mean temperature........27.9°.
Minimum temperature........ 0°. Prevailing wind...........west.

WEATHER SUMMARY FOR FEBRUARY, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	31°	8°	19.5°	.60	W.	Cloudy.
2	14	−2	6	....	W.	Fair.
3	15	2	8.5	....	W.	Clear.
4	26	1	13.5	....	S.W.	Clear.
5	40	15	27.5	.22	S.E.	Cloudy.
6	42	25	33.5	....	N.	Clear.
7	43	18	30.5	....	Variable.	Clear.
8	41	23	32	....	E.	Cloudy.
9	43	24	33.5	....	S.E.	Fair.
10	52	28	40	....	W.	Fair.
11	42	30	36	....	Variable.	Clear.
12	47	34	40.5	.06	S.W.	Fair.
13	45	30	37.5	....	N.E.	Clear.
14	40	25	32.5	.03	E.	Fair.
15	40	26	33	.02	E.	Cloudy.
16	42	9	25.5	.13	W.	Fair.
17	27	7	17	....	W.	Clear.
18	39	18	28.5	.06	S.W.	Cloudy.
19	42	30	36	.03	N.E.	Cloudy.
20	35	32	33.5	1.79	N.E.	Cloudy.
21	41	33	37	4.90	N.E.	Cloudy.
22	44	33	38.5	.20	N.E.	Cloudy.
23	39	31	35	.09	S.W.	Fair.
24	45	29	37	....	S.W.	Clear.
25	45	28	36.5	....	Variable.	Clear.
26	37	23	30	....	W.	Fair.
27	42	20	31	....	W.	Clear.
28	39	22	30.5	....	W.	Clear.
Sum.......	1,078	602	840	8.13	....	....
Mean......	38.5	21.5	30	....	....	....

Maximum temperature...... 52°. Mean temperature........30.0°.
Minimum temperature...... −2.. Prevailing wind...........west.

WEATHER SUMMARY FOR MARCH, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	41°	22°	31.5°	....	N.E.	Fair.
2	43	22	32.5	....	S.W.	Fair.
3	39	29	34	.42	N.E.	Fair.
4	35	23	29	.68	Variable.	Cloudy.
5	41	27	34	....	N.W.	Clear.
6	45	23	34	....	W.	Clear.
7	49	24	36.5	....	S.W.	Fair.
8	47	28	37.5	....	S.	Fair.
9	54	27	40.5	....	S.	Clear.
10	54	30	42	....	S.E.	Clear.
11	58	36	47	....	E.	Clear.
12	54	40	47	....	Variable.	Cloudy.
13	58	45	51.5	....	Variable.	Cloudy.
14	53	34	43.5	....	W.	Clear.
15	48	26	37	....	E.	Clear.
16	40	24	32	....	S.	Cloudy.
17	59	32	45.5	.28	Variable.	Fair.
18	56	31	43.5	....	S.W.	Clear.
19	54	36	45	.58	S.W.	Cloudy.
20	61	41	51	.02	W.	Fair.
21	42	34	38	.03	S.E.	Cloudy.
22	43	29	36	.31	S.E.	Cloudy.
23	59	37	48	.18	S.W.	Cloudy.
24	43	35	39	....	E.	Cloudy.
25	50	29	39.5	....	E.	Clear.
26	51	29	40	....	E.	Fair.
27	52	37	44.5	....	E.	Fair.
28	54	33	43.5	....	S.E.	Fair.
29	44	38	41	.10	S.E.	Cloudy.
30	45	39	42	.59	E.	Cloudy.
31	43	31	37	.53	N.	Fair.
Sum.......	1,515	971	1,243	3.71	....	....
Mean......	48.9	31.3	40.1	....	....	....

Maximum temperature........61°. Mean temperature........40.1°.
Minimum temperature........22°. Prevailing wind........... east.

WEATHER SUMMARY FOR APRIL, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	45°	25°	35°	....	W.	Clear.
2	45	23	34	.04	W.	Fair.
3	36	23	29.5	....	W.	Clear.
4	43	17	30	....	S.W.	Fair.
5	37	29	33	.72	N.E.	Cloudy.
6	38	24	31	....	W.	Clear.
7	44	21	32.5	....	W.	Fair.
8	58	28	43	....	W.	Clear.
9	58	34	46	....	Variable.	Fair.
10	51	36	43.5	.19	E.	Cloudy.
11	54	42	48	....	E.	Cloudy.
12	58	41	49.5	....	N.	Cloudy.
13	61	43	52	....	N.	Fair.
14	51	39	45	....	N.E.	Cloudy.
15	43	38	40.5	.22	N.E.	Cloudy.
16	56	37	46.5	....	W.	Cloudy.
17	71	38	54.5	....	W.	Fair.
18	64	45	54.5	....	N.W.	Fair.
19	45	33	39	.06	E.	Cloudy.
20	58	37	47.5	.38	Variable.	Fair.
21	56	36	46	....	W.	Clear.
22	62	37	49.5	....	S.W.	Cloudy.
23	61	44	52.5	.04	S.W.	Cloudy.
24	55	43	49	2.18	Variable.	Cloudy.
25	47	39	43	....	N.E.	Cloudy.
26	47	34	40.5	.11	N.E.	Cloudy.
27	47	29	38	....	N.E.	Cloudy.
28	37	33	35	1.23	N.E.	Cloudy.
29	41	36	38.5	.39	N.E.	Cloudy.
30	63	39	51	....	W.	Fair.
Sum.......	1,532	1,023	1,277.5	5.56	....	....
Mean......	51.1	34.1	42.6	....	....	....

Maximum temperature........71°. Mean temperature........42.6°.
Minimum temperature........17°. Prevailing wind...........west.

WEATHER SUMMARY FOR MAY, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	68°	45°	56.5°	....	N.W.	Fair.
2	55	41	48	Trace.	Variable.	Cloudy.
3	45	41	43	.31	N.E.	Cloudy.
4	52	39	45.5	....	E.	Cloudy.
5	59	40	49.5	.07	S.W.	Cloudy.
6	60	42	51	.50	Variable.	Cloudy.
7	57	39	48	.18	N.E.	Cloudy.
8	48	33	40.5	1.62	N.E.	Cloudy.
9	54	34	44	....	N.E.	Fair.
10	62	34	48	....	S.W.	Clear.
11	60	40	50	....	S.W.	Fair.
12	65	48	56.5	....	S.	Fair.
13	67	49	58	....	Variable.	Fair.
14	68	48	58	....	N.E.	Clear.
15	60	44	52	.45	Variable.	Cloudy.
16	62	47	54.5	.29	N.	Cloudy.
17	68	47	57.5	.86	W.	Fair.
18	65	45	55	....	S.W.	Clear.
19	68	48	58	.40	S.W.	Fair.
20	83	55	69	....	W.	Cloudy.
21	70	47	58.5	....	E.	Clear.
22	62	41	51.5	....	S.	Clear.
23	65	44	54.5	....	S.E.	Cloudy.
24	55	51	53	.75	S.E.	Cloudy.
25	54	51	52.5	1.67	E.	Cloudy.
26	55	48	51.5	.33	N.E.	Cloudy.
27	65	48	56.5	1.07	N.E.	Cloudy.
28	61	52	56.5	.31	E.	Cloudy.
29	67	54	60.5	....	Variable.	Cloudy.
30	74	54	64	Trace.	S.W.	Fair.
31	72	52	62	.10	N.E.	Fair.
Sum.......	1,926	1,401	1,663.5	8.95	....	....
Mean......	62.1	45.2	53.7	....	....	....

Maximum temperature........83°. Mean temperature........53.7°.
Minimum temperature........33°. Prevailing wind......northeast.

WEATHER SUMMARY FOR JUNE, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	67°	58°	60°	.02	N.E.	Fair.
2	68	58	58	.02	N.E.	Cloudy.
3	63	52	57.5	.01	N.	Cloudy.
4	55	49	52	.04	N.E.	Cloudy.
5	66	49	57.5	....	N.E.	Fair.
6	68	45	56.5	....	S.E.	Fair.
7	75	52	63.5	....	S.W.	Fair.
8	73	52	62.5	....	S.W.	Clear.
9	86	57	71.5	....	S.W.	Fair.
10	71	52	61.5	....	Variable.	Cloudy.
11	69	50	59.5	....	S.	Cloudy.
12	85	58	71.5	.21	S.W.	Fair.
13	80	60	70	.08	Variable.	Cloudy.
14	81	56	68.5	.10	S.W.	Fair.
15	75	53	64	....	N.	Clear.
16	67	43	55	....	Variable.	Clear.
17	74	49	61.5	....	Variable.	Clear.
18	75	53	64	....	Variable.	Fair.
19	73	59	66	....	S.	Fair.
20	75	56	65.5	.05	W.	Clear.
21	71	56	63.5	.09	W.	Fair.
22	74	51	62.5	....	Variable.	Clear.
23	70	49	59.5	....	Variable.	Clear.
24	82	54	68	....	W.	Fair.
25	85	61	73	....	S.W.	Fair.
26	88	66	77	....	W.	Clear.
27	80	62	71	....	Variable.	Fair.
28	73	59	66	.02	E.	Cloudy.
29	77	62	69.5	.13	S.E.	Cloudy.
30	73	59	66	....	Variable.	Cloudy.
Sum.......	2,214	1,630	1,922	.77	....	....
Mean......	73.8	54.3	64.1	....	....	....

Maximum temperature........88°. Mean temperature........64.1°.
Minimum temperature........43°. Prevailing wind.....southwest.

WEATHER SUMMARY FOR JULY, 1898.

	TEMPERATURE.			PRECIPITATION.	PREVAILING WIND.	CHARACTER OF DAY.
	Max.	Min.	Mean.			
1	91°	60°	75.5°	....	W.	Clear.
2	80	62	71	....	Variable.	Clear.
3	95	61	78	....	S.W.	Clear.
4	92	70	81	.20	S.W.	Fair.
5	78	58	68	....	W.	Fair.
6	75	55	65	....	Variable.	Clear.
7	74	52	63	....	S.W.	Fair.
8	81	51	66	....	S.W.	Clear.
9	73	63	68	.42	S.W.	Cloudy.
10	76	53	64.5	....	Variable.	Clear.
11	75	50	62.5	....	S.E.	Fair.
12	72	53	62.5	....	N.E.	Cloudy.
13	62	56	59	5.50	N.E.	Cloudy.
14	77	55	66	....	S.W.	Clear.
15	85	62	73.5	....	W.	Fair.
16	81	62	71.5	....	W.	Clear.
17	82	57	69.5	....	W.	Clear.
18	79	60	69.5	....	Variable.	Cloudy.
19	77	64	70.5	.54	S.W.	Cloudy.
20	80	65	72.5	.05	S.W.	Fair.
21	85	64	74.5	.06	S.W.	Cloudy.
22	73	64	68.5	....	N.E.	Cloudy.
23	77	58	67.5	....	E.	Cloudy.
24	70	62	66	.03	S.E.	Cloudy.
25	72	61	66.5	....	S.E.	Cloudy.
26	80	63	71.5	....	S.W.	Cloudy.
27	78	67	72.5	.05	E.	Cloudy.
28	74	67	70.5	.26	E.	Cloudy.
29	86	68	77	....	S.W.	Cloudy.
30	91	68	79.5	....	S.W.	Fair.
31	86	68	77	....	Variable.	Cloudy.
Sum.......	2,457	1,879	2,168	7.11	....	....
Mean......	79.3	60.6	69.9	....	....	....

Maximum temperature........95°. Mean temperature.........69.9°

Minimum temperature........50°. Prevailing wind.....southwest.

WEATHER SUMMARY FOR AUGUST, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	76°	64°	70°	....	E.	Cloudy.
2	87	67	77	.01	W.	Clear.
3	84	66	75	....	Variable.	Fair.
4	86	67	76.5	.41	S.W.	Fair.
5	79	63	71	.50	W.	Fair.
6	82	58	70	....	W.	Fair.
7	85	58	71.5	....	S.W.	Fair.
8	86	69	77.5	.02	S.W.	Fair.
9	81	69	75	.28	W.	Cloudy.
10	70	65	67.5	2.00	N.	Cloudy.
11	69	61	65	2.14	N.E.	Cloudy.
12	73	60	66.5	Trace.	S.E.	Cloudy.
13	79	64	71.5	.75	S.W.	Fair.
14	78	57	67.5	....	W.	Clear.
15	79	58	68.5	....	S.E.	Clear.
16	81	55	68	....	S.W.	Fair.
17	85	66	75.5	.17	S.W.	Cloudy.
18	84	63	73.5	....	W.	Fair.
19	75	63	69	.17	S.E.	Fair.
20	78	58	68	....	N.W.	Clear.
21	84	55	69.5	....	S.W.	Clear.
22	85	61	73	....	N.W.	Clear.
23	86	66	76	....	S.W.	Fair.
24	87	66	76.5	.31	S.W.	Clear.
25	85	64	74.5	.01	S.	Fair.
26	79	62	70.5	....	N.W.	Clear.
27	75	56	65.5	.08	N.W.	Fair.
28	73	49	61	....	Variable.	Clear.
29	73	51	62	....	S.E.	Fair.
30	84	63	73.5	....	S.W.	Fair.
31	88	66	77	....	S.W.	Fair.
Sum.......	2,496	1,910	2,203	6.85	....	....
Mean......	80.5	61.6	71	....	....	....

Maximum temperature........88°. Mean temperature..........71°.
Minimum temperature........49°. Prevailing wind.....southwest.

WEATHER SUMMARY FOR SEPTEMBER, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	92°	68°	80°	.14	S.W.	Fair.
2	91	68	79.5	.10	S.W.	Fair.
3	90	65	77.5	....	W.	Fair.
4	88	66	77	....	S.W.	Fair.
5	85	70	77.5	....	S.W.	Cloudy.
6	87	66	76.5	....	S.W.	Clear.
7	83	64	73.5	.12	S.W.	Cloudy.
8	70	56	63	....	N.W.	Cloudy.
9	76	52	64	....	N.E.	Clear.
10	77	52	64.5	....	Variable.	Clear.
11	68	45	56.5	....	W.	Clear.
12	70	47	58.5	....	N.E.	Clear.
13	68	43	55.5	....	Variable.	Clear.
14	72	45	58.5	....	S.E.	Clear.
15	73	45	59	....	E.	Cloudy.
16	75	60	67.5	....	N.E.	Cloudy.
17	78	63	70.5	....	S.W.	Cloudy.
18	74	61	67.5	....	S.W.	Fair.
19	78	52	65	....	S.W.	Clear.
20	68	44	56	....	W.	Clear.
21	65	38	51.5	....	W.	Clear.
22	70	43	56.5	....	S.W.	Cloudy.
23	76	58	67	1.41	S.W.	Cloudy.
24	71	46	58.5	.02	Variable.	Cloudy.
25	58	44	51	.03	N.E.	Cloudy.
26	71	51	61	.29	S.W.	Cloudy.
27	66	46	56	....	N.W.	Clear.
28	78	48	58	....	W.	Clear.
29	72	49	60.5	....	Variable.	Clear.
30	77	52	64.5	....	S.W.	Clear.
Sum.......	2,262	1,602	1,932	2.11	....	....
Mean......	75.4	53.4	64.4	....	....	....

Maximum temperature.........92°. Mean temperature.........64.4°.
Minimum temperature.........38°. Prevailing wind.....southwest.

WEATHER SUMMARY FOR OCTOBER, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	80°	52°	66°	....	S.W.	Clear.
2	73	56	64.5	....	E.	Cloudy.
3	75	57	66	....	S.W.	Cloudy.
4	77	61	69	....	S.W.	Cloudy.
5	71	65	68	1.57	S.	Cloudy.
6	67	45	56	....	N.	Clear.
7	62	39	50.5	....	S.E.	Clear.
8	61	48	54.5	.33	W.	Fair.
9	65	42	53.5	....	W.	Clear.
10	57	34	45.5	....	S.E.	Clear.
11	70	43	56.5	....	S.E.	Fair.
12	67	50	58.5	.84	Variable.	Fair.
13	59	39	49	....	E.	Clear.
14	59	43	51	.19	E.	Cloudy.
15	55	43	49	1.27	W.	Cloudy.
16	53	39	46	....	W.	Clear.
17	53	33	43	....	N.	Clear.
18	49	31	40	....	N.E.	Cloudy.
19	58	41	49.5	1.91	Variable.	Cloudy.
20	66	45	55.5	....	Variable.	Clear.
21	52	43	47.5	.08	N.E.	Cloudy.
22	66	52	59	3.45	S.W.	Cloudy.
23	60	41	50.5	....	W.	Clear.
24	62	38	50	....	S.W.	Clear.
25	65	46	55.5	....	S.	Fair.
26	63	56	59.5	1.68	S.E.	Cloudy.
27	61	35	48	.57	W.	Clear.
28	52	30	41	....	N.E.	Fair.
29	47	39	43	....	N.	Cloudy.
30	48	42	45	.16	W.	Cloudy.
31	53	34	43.5	....	W.	Fair.
Sum.......	1,906	1.362	1,634	12.05	....	....
Mean......	61.5	43.9	52.7	....	....	....

Maximum temperature........80°. Mean temperature........52.7°.
Minimum temperature........30°. Prevailing wind...........west.

WEATHER SUMMARY FOR NOVEMBER, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	53°	42°	47.5°	....	S.W.	Clear.
2	60	42	51	....	S.W.	Clear.
3	59	38	48.5	....	S.W.	Clear.
4	60	34	47	....	S.W.	Clear.
5	56	38	47	....	S.E.	Cloudy.
6	59	41	50	.51	N.	Cloudy.
7	45	31	38	....	W.	Clear.
8	56	29	42.5	....	S.W.	Fair.
9	60	40	50	....	E.	Fair.
10	58	43	50.5	1.18	N.E.	Cloudy.
11	59	33	46	.26	W.	Fair.
12	46	24	35	....	W.	Clear.
13	52	30	41	.01	S.W.	Cloudy.
14	50	36	43	.44	W.	Fair.
15	47	27	37	....	W.	Clear.
16	51	30	40.5	....	S.W.	Fair.
17	47	36	41.5	.55	N.E.	Cloudy.
18	48	43	45.5	.02	N.E.	Cloudy.
19	44	39	41.5	1.95	N.	Cloudy.
20	49	37	43	....	W.	Fair.
21	50	28	39	....	S.W.	Clear.
22	42	31	36.5	....	N.E.	Fair.
23	46	33	39.5	....	N.E.	Cloudy.
24	40	33	36.5	.32	N.E.	Cloudy.
25	33	22	27.5	....	W.	Clear.
26	31	18	24.5	.40	N.E.	Cloudy.
27	32	22	27	1.10	N.E.	Cloudy.
28	37	22	29.5	....	N.W.	Cloudy.
29	42	19	30.5	....	S.W.	Cloudy.
30	33	26	29.5	.70	Variable.	Cloudy.
Sum	1,445	967	1,206	7.44	....	....
Mean	48.2	32.2	40.2	....	....	....

Maximum temperature........60°.   Mean temperature........40.2°.
Minimum temperature........18°.   Prevailing wind.....southwest.

WEATHER SUMMARY FOR DECEMBER, 1898.

	Temperature.			Precipitation.	Prevailing wind.	Character of day.
	Max.	Min.	Mean.			
1	38°	27°	32.5°	....	W.	Clear.
2	40	19	29.5	....	S.W.	Clear.
3	37	26	31.5	....	N.E.	Cloudy.
4	40	33	36.5	.17	N.E.	Cloudy.
5	47	33	40	.36	S.W.	Fair.
6	38	30	34	....	W.	Fair.
7	38	24	31	....	W.	Clear.
8	32	21	26.5	....	W.	Clear.
9	25	17	21	....	W.	Clear.
10	28	17	22.5	....	S.W.	Fair.
11	30	22	26	....	W.	Clear.
12	36	20	28	.08	Variable.	Cloudy.
13	28	4	16	....	W.	Fair.
14	23	—4	9.5	....	W.	Clear.
15	35	7	21	....	S.W.	Clear.
16	40	17	28.5	....	S.W.	Clear.
17	43	25	34	....	Variable.	Cloudy.
18	42	31	36.5	....	W.	Clear.
19	33	23	28	....	N.E.	Fair.
20	36	26	31	.63	Variable.	Cloudy.
21	35	30	32.5	.04	N.E.	Foggy.
22	39	30	34.5	.26	E.	Foggy.
23	49	32	40.5	.79	W.	Fair.
24	40	25	32.5	....	S.W.	Cloudy.
25	35	25	30	....	W.	Cloudy.
26	34	21	27.5	....	N.	Clear.
27	38	17	27.5	Trace.	S.W.	Fair.
28	32	8	20	....	W.	Clear.
29	43	8	25.5	....	S.W.	Fair.
30	50	35	42.5	Trace.	S.W.	Fair.
31	47	24	35.5	.38	N.	Cloudy.
Sum	1,151	673	912	2.71	....	....
Mean	37.1	21.7	29.4	....	....	....

Maximum temperature...... 50°.
Minimum temperature ...... —4°

Mean temperature........29.4°.
Prevailing wind...........west.

WEATHER SUMMARY FOR YEAR 1898.

MONTH.	Number of clear days.	Number of fair days.	Number of cloudy days.	Number of days with precipitation of .01 inch or more.	Prevailing wind.	Precipitation in inches.
January	7	14	10	11	W.	6.83
February	11	8	9	12	W.	8.12
March	9	11	11	11	E.	3.71
April	5	9	16	11	W.	5.56
May	5	9	17	15	N.E.	8.95
June	8	13	9	11	S.W.	.77
July	9	7	15	9	S.W.	7.11
August	9	16	6	13	S.W.	6.85
September	14	5	11	7	S.W.	2.11
October	12	6	13	11	W.	12.05
November	9	7	14	12	S.W.	7.44
December	12	9	10	8	W.	2.71
Totals	110	114	141	131	....	72.21

DONATIONS—1898.

Books.

W. C. Stubbs—Sugar Cane.

E. L. Freeman—Annual Report of the Railroad Commissioner of Rhode Island, 1897.

Robert Manning, Secretary—Transactions of the Massachusetts Horticultural Society, 1897. Parts I and II.

Wm. H. Barnes, Secretary—Transactions of the Kansas State Horticultural Society, Vol. XXII, 1897.

Wm. H. Barnes, Secretary—Papers read before the 31st Annual Meeting of the Kansas State Horticultural Society, December 28, 29, 30, 1897.

Dr. M. Hollrung—Handbuch der chemischen Mittel gegen Pflanzenkrankheiten.

Dr. Leonard Pearson—The Veterinary Profession.

Missouri Botanical Garden—Ninth Annual Report, 1898.

F. D. Coburn, Secretary—Report of the Kansas State Board of Agriculture, quarter ending March, 1898.

Wm. R. Sessions, Secretary—Forty-Fifth Annual Report of the Secretary of the Massachusetts State Board of Agriculture, 1897.

Charles A. Wieting, Commissioner—Fourth Annual Report of the Department of Agriculture of the State of New York, 1897. Three volumes.

Boston Public Library, Boston, Mass.—Forty-Sixth Annual Report, 1897–98.

Epitomist Publishing Co., Indianapolis, Ind.—Practical Poultry Culture.

SEEDS, PLANTS, AND POULTRY SUPPLIES.

W. Atlee Burpee & Co., Philadelphia, Pa.—Twenty-four packages vegetable seeds; twenty-four packages flower seeds.

Slaymaker & Son, Dover, Del.—Two dozen Phenix strawberry plants.

Peter Henderson & Co., New York City—Thirteen packages vegetable seeds.

Adler Color and Chemical Works—Ten pounds green arsenite.

Nichols Chemical Co.—Twenty pounds laurel green.

Mackenzie & Winslow, Fall River, Mass.—One pail American Triumph Poultry Food.

Standard Harrow Co., Utica, N. Y.—One Standard Spring-Tooth Harrow.

The Bartle Poultry Supply Co., Oxford, N. Y.—One dozen Improved Egg Boxes.

Twentieth Century Mfg. Co., St. Louis, Mo.—One Century Egg Carrier.

Amos Keyes & Co., Boston, Mass.—One Fletcher's Egg Case.

Samuel H. Houghton, Harvard, Mass.—One Wire Egg Carrier.

Geo. E. Smith, East Norton, Mass.—One trio Muscovy ducks.

Geo. H. Pollard, South Attleboro, Mass.—One trio Pekin ducks.

Charles J. Fogg, Waltham, Mass.—Five Ideal Leg Bands.

A. J. Silberstein, Framingham, Mass.—Trio Light Brahmas.

Star Incubator and Brooder Co., Bound Brook, N. J.—Star Incubator, 130 eggs size.

Wilson Bros., Easton, Pa.—Daisy Bone Cutter.

Cyphers Incubator Co., Wayland, N. Y.—One Cyphers Brooder.

Jos. Breck & Sons, Boston, Mass.—Sample dozen Zuckers Medicol Eggs.

Worcester Compound Co., Worcester, Mass.—Sample P. D. Q. Powder.

Granite State Evaporator Co., New York, N. Y.—One twenty-five gallon Cooker.

The Zenner-Raymond Disinfectant Co., Detroit, Mich.—One can Zenoleum.

Atsatt Bros., Mattapoisett, Mass.—Poultry Fountain.

Keyes & Davis, Battle Creek, Mich.—Sample Climax Leg Bands.

C. H. Canfield, Bath, N. Y.—Canfield Coop, No. 24.

York Chemical Co., York, Pa.—Samples of Poultry Foods.

I. J. True, Hope Valley, R. I.—One dozen True's Adjustable Rings for Distinguishing Fowls.

W. J. Decker & Co., Cresskill, N. J.—Incubator Thermometer and Leg Bands.

O. H. Robertson, Forestville, Conn.—Sample Chain Hanging Cattle Stanchion.

J. Y. Bicknell, Buffalo, N. Y.—Sample Leg Bands.

Smith & Romaine, New York City.—Sample bag Boiled Beef and Bone.

F. P. Knowles, Guilford, Conn.—Sample bag Sea Shells.

Skabcura Dip Co., St. Louis, Mo.—Nikoteen for insecticide.

D. J. Lambert, Apponaug, R. I.—Sample "Death to Lice."

Evans Mfg. Co., Ypsilanti, Mich.—Evans' No. 5 Vegetable and Root Cutter.

EXCHANGES.

A Few Hens, Boston, Mass.
Agricultural Epitomist, Indianapolis, Ind.
Agricultural Student, Columbus, Ohio.
American Agriculturist, New York, N. Y.
American Cider and Vinegar Maker, New York, N. Y.
American Cultivator, Boston, Mass.
American Fancier, Johnstown, N. Y.
American Horse Breeder, Boston and New York.
American Poultry Advocate, Syracuse, N. Y.
American Poultry Journal, Chicago, Ill.
California Cultivator and Poultry Keeper, Los Angeles, Cal.
Colorado Poultry Journal, Denver, Colo.
Connecticut Farmer, Hartford, Conn.
Cotton Planters' Journal, Memphis, Tenn.
Elgin Dairy Report, Elgin, Ill.
Fanciers' Magazine, Worcester, Mass.
Fancy Fowls, Hopkinsville, Kentucky.
Farm and Home, Springfield, Mass.
Farmer's Guide, Huntington, Ind.
Farmer's Magazine, Springfield, Ill.
Farmers' Voice, Chicago, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farm, Stock and Home, Minneapolis, Minn.
Fancier, Graham, N. C.
Fanciers' Review, Chatham, N. Y.
Farming World, Clinton, Iowa.
Farm News, Springfield, Ohio.

Farm Poultry, Boston, Mass.
Feather, Washington, D. C.
Feathered World, London, England.
Gentleman Farmer Magazine, Chicago, Ill.
Green's Fruit Grower, Rochester, N. Y.
Hoard's Dairyman, Fort Atkinson, Wis.
Holstein-Friesian Register, Brattleboro, Vt.
Homestead, Des Moines, Iowa.
Hospodářské Listy, Chicago, Ill.
Indiana Farmer, Indianapolis, Ind.
Louisiana Planter, New Orleans, La.
Loft, Burrow and Aviary, Worcester, Mass.
Market Basket, Philadelphia, Pa.
Market Garden, Minneapolis, Minn.
Massachusetts Ploughman, Boston, Mass.
Mirror and Farmer, Manchester, N. H.
Montana Fruit Grower, Missoula, Mont.
National Stockman and Farmer, Pittsburg, Pa.
Nebraska Farmer, Omaha, Neb.
New England Fancier, Yarmouthport, Mass.
New England Farmer, Boston, Mass.
New England Florist, Boston, Mass.
New England Homestead, Springfield, Mass.
Ohio Farmer, Cleveland, Ohio.
Ohio Poultry Journal, Dayton, Ohio.
Our Grange Homes, Boston, Mass.
Pigeon Keeper's Guide, Medford, Mass.
Poultry Herald, St. Paul, Minn.
Poultry Keeper, Parkesburg, Pa.
Poultry Monthly, Albany, N. Y.
Practical Dairyman, Chatham, N. Y.
Practical Farmer, Philadelphia, Pa.
Practical Poultryman, Whitney's Point, N. Y.
Reliable Poultry Journal, Quincy, Ill.
Ruralist, Federalsburg, Md.

Rural New Yorker, New York, N. Y.
Southern Fancier, Atlanta, Ga.
Southern Farm Magazine, Baltimore, Md.
Southern Letter, Tuskegee, Ala.
Southern Planter, Richmond, Va.
Southwestern Farmer and American Horticulturist, Wichita, Kansas.
Stock Keeper, Boston, Mass.
The Strawberry Specialist, Kittrell, N. C.
Sugar Beet, Philadelphia, Pa.
The Southwest, Springfield, Mo.
Vermont Farmers' Advocate, Burlington, Vt.
Wallaces' Farmer, Des Moines, Iowa.
Western Creamery, San Francisco, Cal.
Western Fruit Grower, St Joseph, Mo.
West Virginia Farm Review, Charlestown, W. Va.
Wool Record, New York, N. Y.

LIST OF STATION PUBLICATIONS FROM ORGANIZATION TO DATE.

Year.	Number.		Title.	Pages.
*1888.	First Annual Report.		Report of Board of Managers..	27
*1889.	Bull.	1.	Organization of Experiment Station....................	12
* "	"	2.	The Farm, Historical, Physical, and Geological Description	16
* "	"	3.	Stock Feeding...	40
* "	"	4.	Bee Keeping. Establishment of the Apiary............	32
* "	"	5.	Potatoes. Meteorological Summary.................. .	10
"	Second Annual Report.		Report of the Director. Reprints of Bulletins 1 to 4, inclusive, and brief reports of the heads of Divisions.....	124
*1890.	Bull.	6.	Milk Fever, or Parturient Apoplexy in Cows	24
* "	"	7.	Catalogue of Fruits. Meteorological Summary. Report of the Apiarist........................	40
* "	"	8.	Soils and Fertilizers..............	34
* "	"	9.	Experiments in Apiculture...........................	24
* "	Third Annual Report.		Report of Director. Crops and Field Experiments. Coöperative Field Experiments with Fertilizers on Indian Corn. Experiments with Potatoes (varieties). Experiments with Bordeaux Mixture as a Preventive of the Potato Blight. Trials of Varieties of Fruits and Vegetables. Reports of Divisions.......	196
*1891.	Bull.	10.	Mixed Foods in Cases of Faulty Appetite in Horses and Neat Stock: Including Notice of Patented and Proprietary Foods. Sore Shoulders in Horses............	8
* "	"	11.	The State Fertilizer Law as it is and as it might be. Commercial Valuations of Fertilizer Stock. Analyses of Commercial Fertilizers, State Inspection, 1891. Analyses of Miscellaneous Materials. Meteorological Summary.	20
* "	"	12.	Further Analyses of Commercial Fertilizers Collected under the State Inspection, 1891, with Comments......	12

* Out of print.

Year.	Number.	Title.	Pages.
*1891.	Bull. 13.	Concluded list of Fertilizer Analyses, State Inspection, 1891. Analyses of Miscellaneous Materials...........	18
* "	" 14.	Notes on the Potato Scab and Bordeaux Mixture as a Preventive of Potato Scab and of Potato Blight. Notes on Transplanting Onions.......	18
*1892.	Fourth Annual Report.	Report of Director. Field and Plot Experiments. Coöperative Field Experiments with Fertilizers on Indian Corn. Brief Reports of Divisions....................	118
* "	Bull. 15.	Treatment of Loose Smut of Oats. Fungicides and Insecticides. Black Rot of the Grape, and Apple Scab, Codling Moth, Cankerworm and Plum Curculio.	25
"	" 16.	The New Fertilizer Law for Rhode Island. Selling Price of Fertilizer Stock. Analyses of Commercial Fertilizers; State Inspection, 1892. Miscellaneous Analyses...	16
"	" 17.	Analyses of Commercial Fertilizers, State Inspection, 1892..........	8
"	" 18.	Analyses of Commercial Fertilizers, State Inspection, 1892. A word of Caution in the Purchase of Wood Ashes..........................	8
"	" 19.	Concluded List of Fertilizer Analyses, with Summaries and Comments...............	12
* "	" 20.	The Production of Capons. Experiments in Caponizing. Prices of Capons, Broilers, Roasters and Fowls in Boston and New York Markets. When to Make Capons, the Time to Sell, and How to Prepare for Market. Caponizing Tools, and How to Perform the Operation..........	42
* "	Fifth Annual Report.	Report of Director. Winter and Spring Application of Ashes to Newly Seeded Meadow. Shrinkage in Curing Field Corn. Tests of Varieties of Oats. Jensen Hot Water Treatment for Prevention of Smut of Oats. Fertilizer Experiments with Oats. Trials of Different Forms of Phosphates. Trials of Muskmelons. Leguminous Crops. Coöperative Field Experiments on Indian Corn. Potato Scab. Trial of Lawn Grasses. Remedies for the Rose-Bug. Crossbreeding of Poultry. Reports of Divisions......... .	140

* Out of print.

Year.	Number.	Title.	Pages.
1893.	Bull. 21.	Sea-Weeds, Agricultural Value and Chemical Composition	40
"	" 22.	Strawberries. Cultivation and Varieties	22
"	" 23.	Fertilizers. Commercial and Miscellaneous	18
"	" 24.	Fertilizers. Analyses of Commercial.	8
* "	" 25.	Turkeys. Experiments with; Management of, by Successful Producers; Wild Turkey Crosses, Their Desirability, and Where They may be Obtained	42
"	" 26.	Fertilizers. Oats. Potato Scab	32
"	Sixth Annual Report.	Report of Director. Rotation of Crops. Coöperative Field Experiments. On the Occasional Ill Effect of Sulfate of Ammonia as a Manure, and the Use of Air-slacked Lime in Overcoming the Same. On the Effect of Air-slacked Lime Used in Connection with Certain Forms of Organic Nitrogen. Applying Liquid Manure with Hydrant Water. New Varieties of Strawberries. Seed Examination. Experiments with Turkeys. Diseases of Turkeys. Reports of Divisions	165
1894.	Bull. 27.	Leaf Blight of the Pear. Raspberries; Distribution of Plants	12
"	" 28.	Rhode Island Soils. Fertilizers	32
"	" 29.	Fertilizers. Commercial and Special Formula	16
"	" 30.	Fertilizers. Potato Scab	30
Leaf-lets.	Circular Bull. 1.	Plan of Soil Test. Coöperative Test of Varieties of Vegetables and Field Seeds.	
	" 2.	Request for Information Regarding "Black Head" of Turkeys.	
	" 3.	List of Experiments in Progress.	
1894.	Seventh Annual Report.	Report of Director. Field Experiments. Soil Test with Fertilizers and Plants. Growth of Various Plants upon an Upland Acid Soil Before and After Liming. On the Substitution of Soda for, and Its Value in Connection with, Potash. On the Fungous Parasites of the Apple and Pear. Infectious Disease of Turkeys. Reports of Divisions	135
1895.	Bull. 31.	Some Special Orchard Treatment of the Apple, Pear and Quince	18

* Out of print.

BULLETINS

AND

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OF THE

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION,

FOR THE

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INDEX

OF THE

BULLETINS AND ANNUAL REPORT

OF THE

Rhode Island Agricultural Experiment Station.

FOR THE YEAR 1898.

NOTE.—For pp. 1-10 see Bul. 47; for pp. 11-34 see Bul. 48; for pp. 35-54 see Bul. 49; for pp. 55-62 see Bul. 50; for pp. 63-70 see Bul. 51.

NOTE.—For pp. 1-10 see Bul. 47; for pp. 11-34 see Bul. 48; for pp. 35-54 see Bul. 49; for pp. 55-62 see Bul. 50; for pp. 63-70 see Bul. 51.

NOTE.—For pp. 1-10 see Bul. 47; for pp. 11-34 see Bul. 48; for pp. 35-54 see Bul. 49; for pp. 55-62 see Bul. 50; for pp. 63-70 see Bul. 51.

NOTE.—For pp. 1-10 see Bul. 47; for pp. 11-34 see Bul. 48; for pp. 35-54 see Bul. 49; for pp. 55-62 see Bul. 50; for pp. 63-70 see Bul. 51.

NOTE.—For pp. 1-10 see Bul. 47; for pp. 11-34 see Bul. 48; for pp. 35-54 see Bul. 49; for pp. 55-62 see Bul. 50; for pp. 63-70 see Bul. 51.

NOTE.—For pp. 1-10 see Bul. 47; for pp. 11-34 see Bul. 48; for pp. 35-54 see Bul. 49; for pp. 55-62 see Bul. 50; for pp. 63-70 see Bul. 51.

Agricultural Experiment Station

1898.

Annual Report

PART II.
COLLEGE CATALOGUE
IS PART I.

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